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Decameron Physiologicum:

OR, TEN

DIALOGUES

OF

NATURAL

Philosophy.

By *THOMAS HOBBES* of *Malmsbury*.

To which is added

The Proportion of a straight Line to half the Arc of a Quadrant.

By the same AUTHOR.

LONDON:

Printed by *J. C.* for *W. Crook* at the *Green Dragon* without Temple-Bar. 1678.

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CAP.

Cap. I.

Of the Original of Natural Philoſophy.

A. Have heard exceeding highly commended a kinde of thing which I do not well underſtand, though it be much talkt of, by ſuch as have not otherwiſe much to do, by the name of *Philoſophy*. And the ſame again by others as much deſpiſed and derided. So that I cannot tell whether it be good or ill, nor what to make of it, though I ſee many other men that thrive by it.

B. I doubt not, but what ſo many do ſo highly praiſe muſt be very admirable, and what is derided and ſcorn'd by many, fooliſh and ridiculous. The honour and ſcorn falleth finally not upon Philoſophy, but upon the Profeſſors. Philoſophy is *The knowledge of Natural Cauſes*. And there is no Knowledge but of Truth. And to know the true

Cauſes of things, was never in contempt, but in admiration. Scorn can never faſten upon Truth. But the difference is all in the Writers and Teachers. Whereof ſome have neither ſtudied, nor care for it, otherwiſe than as a Trade to maintain themſelves or gain Preferment; and ſome for Faſhion, and to make themſelves fit for ingenious Company: and their ſtudy hath not been meditation, but acquieſcence in the Authority of thoſe Authors whom they have heard commended. And ſome (but few) there be, that have ſtudied it for Curioſity, and the delight which commonly men have in the acquiſition of Science, and in the maſtery of difficult and ſubtil Doctrines. Of this laſt ſort I count *Ariſtotle*, and a few others of the Ancients, and ſome few Moderns: and to theſe it is that properly belong the Praiſes which are given to Philoſophy.

A. If I have a minde to ſtudy (for example Natural Philoſophy) muſt I then needs read *Ariſtotle*, or ſome of thoſe that now are in requeſt?

B. There's no neceſſity of it. But if in your own meditation you light upon a difficulty, I think 'tis no loſs of time, to enquire what other men ſay of it, but to rely onely upon Reaſon. For though there be ſome few Effects of Nature (eſpecially concerning the Heavens) whereof the Philoſophers of old time have aſſigned very rational Cauſes, ſuch as

as any man may acquiesce in, as of Eclipses of the Sun and Moon by long observation, and by the Calculation of their visible Motions; yet what is that to the numberless and quotidian *Phænomena* of Nature? Who is there amongst them or their Successors, that has satisfied you with the Causes of Gravity, Heat, Cold, Light, Sense, Colour, Noise, Rain, Snow, Frost, Winds, Tides of the Sea, and a thousand other things which a few mens lives are too short to go through, and which you and other curious Spirits admire (as quotidian as they are) and fain would know the Causes of them, but shall not finde them in the Books of Naturalists; and when you ask what are the Causes of any of them, of a Philosopher now, he will put you off with mere words; which words, examined to the bottom, signifie not a jot more than I cannot tell, or Because it is: Such as are Intrinsecal quality, Occult quality, Sympathy, Antipathy, Antiperistasis, and the like. Which pass well enough with those that care not much for such wisdom, though wise enough in their own ways; but will not pass with you that ask not simply what's the Cause, but in what manner it comes about that such Effects are produced.

A. That's Cozening. What need had they of that? When began they thus to play the *Charletans?*

B: Need had they none. But know you

not that men from their very birth, and naturally, ſcramble for every thing they covet, and would have all the world, if they could, to fear and obey them? If by fortune or induſtry one light upon a Secret in Nature, and thereby obtain the credit of an extraordinary Knowing man, ſhould he not make uſe of it to his own benefit? There is ſcarce one of a thouſand but would live upon the charges of the people as far as he dares. What poor Geometrician is there, but takes pride to be thought a Conjurer? what Mountebank would not make a living out of a falſe opinion that he were a great Phyſician? And when many of them are once engaged in the maintenance of an Errour, they will joyn together for the ſaving of their Authority to decry the Truth.

A. I pray, tell me, if you can, how and where the ſtudy of Philoſophy firſt began.

B. If we may give Credit to old Hiſtories, the firſt that ſtudyed any of the Natural Sciences were the Aſtronomers of *Æthiopia*. My Author is *Diodorus Siculus*, accounted a very faithful Writer, who begins his Hiſtory as high as is poſſible, and tells us that in *Æthiopia* were the firſt Aſtronomers; and that for their Predictions of Eclipſes, and other Conjunctions and Aſpects of the Planets, they obtained of their King not onely Towns and Fields to a third part of the whole Land, but were alſo

in ſuch veneration with the People, that they were thought to have diſcourſe with their Gods, which were the Stars; and made their Kings thereby to ſtand in awe of them, that they durſt not either eat or drink but what and when they preſcribed; no nor live, if they ſaid the Gods commanded them to die. And thus they continued in ſubjection to their falſe Prophets, till by one of their Kings, called *Ergamenes*, (about the time of the *Ptolemies*) they were put to the Sword. But long before the time of *Ergamenes*, the Race of theſe Aſtrologers (for they had no Diſciples but their own Children) was ſo numerous, that abundance of them (whether ſent for or no I cannot tell) tranſplanted themſelves into *Egypt*, and there alſo had their Cities and Lands allowed them, and were in requeſt not onely for Aſtronomy and Aſtrologie, but alſo for Geometry. And *Egypt* was then as it were an Univerſity to all the world, and thither went the curious Greeks, as *Pythagoras*, *Plato*, *Thales*, and others, to fetch Philoſophy into *Greece*. But long before that time, abundance of them went into *Aſſyria*, and had their Towns and Lands aſſigned them alſo there; and were by the *Hebrews* called *Chaldies*.

A. Why ſo?

B. I cannot tell; but I finde in *Martinius* Lexicon they were called *Chaſdim*, and *Cheſdim*, and (as he ſaith) from one *Cheſed* the

ſon of *Nachor*; but I finde no ſuch man as *Cheſed* amongſt the iſſue of *Noah* in the Scripture. Nor do I finde that there was any certain Country called *Chaldæa*; though a Town where any of them inhabited were called A Town of the *Chaldies*. *Martinius* ſaith further, that the ſame word *Chaſdim* did ſignifie alſo *Demons*.

A. By this reckoning I ſhould conjecture they were called *Chuſdim*, as being a Race of *Ethiopians*. For the Land of *Chus* is *Æthiopia*; and ſo the name degenerated firſt into *Chuldim*, and then into *Chaldim*; ſo that they were ſuch another kinde of people as we call *Gypſies*; ſaving that they were admired and feared for their Knavery, and the Gypſies counted Rogues.

B. Nay pray, except *Claudius Ptolomæus*, Author of that great Work of Aſtronomy, the *Almegeſt*.

A. I grant he was excellent both in Aſtronomy and Geometry, and to be commended for his *Almegeſt*; but then for his Judiciar Aſtrologie annexed to it, he is again a Gypſie. But the *Greeks* that travelled (you ſay) into *Egypt*, what Philoſophy did they carry home?

B. The Mathematiques and Aſtronomy. But for that ſublunary Phyſiques, which is commonly called *Natural Philoſophy*, I have not read of any Nation that ſtudied it earlier than the *Greeks*, from whom it proceeded to the

Ro-

Romans. Yet both *Greeks* and *Romans* were more addicted to Moral than to Natural Philoſophy; in which kinde we have their Writings, but looſly and incoherently, written upon no other Principles than their own Paſſions and Preſumptions, without any reſpect to the Laws of Common-wealth, which are the ground and meaſure of all true Morality. So that their Books tend rather to teach men to cenſure than to obey the Laws. Which has been a great hinderance to the Peace of the Weſtern world ever ſince. But they that ſeriouſly applied themſelves to Natural Philoſophy were but few, as *Plato* and *Ariſtotle*, whoſe Works we have; and *Epicurus*, whoſe Doctrine we have in *Lucretius*. The Writings of *Philolaus* and many other curious Students being by fire or negligence now loſt: though the Doctrine of *Philolaus* concerning the Motion of the Earth have been revived by *Copernicus*, and explained and confirmed by *Galileo* now of late.

A. But methinks the Natural Philoſophy of *Plato* and *Ariſtotle*, and the reſt, ſhould have been cultivated and made to flouriſh by their Diſciples.

B. Whom do you mean, the Succeſſors of *Plato*, *Epicurus*, *Ariſtotle*, and the other firſt Philoſophers? It may be ſome of them may have been learned and worthy men. But not long after, and down to the time of our Sa-

viour and his Apoſtles, they were for the moſt part a ſort of needy, ignorant, impudent cheating fellows, who by the profeſſion of the Doctrine of thoſe firſt Philoſophers, got their living. For at that time, the name of Philoſophy was ſo much in faſhion and honour amongſt great perſons, that every rich man had a Philoſopher of one Sect or another to be a Schoolmaſter to his Children. And theſe were they that faining Chriſtianity, with their diſputing and readineſs of talking got themſelves into Chriſtian Commons, and brought ſo many Hereſies into the Primitive Church, every one retaining ſtill a tang of what they had been us'd to teach.

A. But thoſe Hereſies were all condemned in the firſt Council of *Nice*.

B. Yes. But the *Arrian* Hereſie for a long time flouriſhed no leſs than the *Roman*, and was upheld by divers Emperours, and never fully extinguiſhed as long as there were *Vandals* in Chriſtendom. Beſides, there aroſe daily other Sects, oppoſing their Philoſophy to the Doctrine of the Councils concerning the Divinity of our Saviour; as, how many Perſons he was, how many Natures he had. And thus it continued till the time of *Charlemain*, when he and Pope *Leo* the third divided the Power of the Empire into Temporal and Spiritual.

A. A very unequal diviſion.

B. Why?

B. Why? Which of them think you had the greater ſhare?

A. No doubt, the Emperour: For he onely had the Sword.

B. When the Swords are in the hands of men, whether had you rather command the Men or the Swords?

A. I underſtand you. For he that hath the hands of the Men, has alſo the uſe both of their Swords and ſtrength.

B. The Empire thus divided into Spiritual and Temporal, the freedom of Philoſophy was to the power Spiritual very dangerous. And for that cauſe it behoved the Pope to get Schools ſet up not onely for Divinity, but alſo for other Sciences, eſpecially for Natural Philoſophy. Which when by the power of the Emperour he had effected, out of the mixture of *Ariſtotle*'s Metaphyſicks with the Scripture, there aroſe a new Science called *School-Divinity*; which has been the principal Learning of theſe *Weſtern* parts from the time of *Charlemain* till of very late.

A. But I finde not in any of the Writings of the School-men in what manner, from the cauſes they aſſigne, the Effect is naturally and neceſſarily produced.

B. You muſt not wonder at that. For you enquire not ſo much, when you ſee a change of any thing, what may be ſaid to be the cauſe of it, as how the ſame is generated; which

generation

generation is the entire progreſs of Nature from the efficient cauſe to the Effect produced. Which is always a hard Queſtion, and for the moſt part impoſſible for a man to anſwer to. For the alterations of the things we perceive by our five Senſes are made by the motion of Bodies (for the moſt part) either for diſtance, ſmalneſs, or tranſparence, inviſible.

A. But what need had they then to aſſigne any cauſe at all, ſeeing they could not ſhew the Effect was to follow from it?

B. The Schools (as I ſaid) were erected by the Pope and Emperour, but directed by the Pope onely, to anſwer and confute the Hereſies of the Philoſophers. Would you have them then betray their Profeſſion and Authority, that is to ſay, their Livelihood, by confeſſing their ignorance? Or rather uphold the ſame, by putting for cauſes, ſtrange and unintelligible words; which might ſerve well enough not onely to ſatisfie the people whom they relied on, but alſo to trouble the Philoſophers themſelves to finde a fault in.

A. Seeing you ſay that Alteration is wrought by the Motion of *Bodies*, pray tell me firſt what I am to underſtand by the word *Body*.

B. It is a hard Queſtion, though moſt men think they can eaſily anſwer it, as that it is whatſoever they can ſee, feel, or take notice of by their Senſes. But if you will know indeed what is body, we muſt enquire firſt what there

is

is that is *not Body*. You have ſeen (I ſuppoſe) the Effects of Glaſſes, how they multiply and magnifie the Object of our ſight; as when a Glaſs of a certain Figure will make a Counter or a Shilling ſeem twenty, though you be well aſſured there is but one. And if you ſet a mark upon it, you will finde the mark upon them all. The Counter is certainly one of thoſe things we call Bodies: Are not the others ſo too?

A. No, without doubt. For looking through a Glaſs cannot make them really more than they are.

B. What then be they but fancies, ſo many fancies of one and the ſame thing in ſeveral places?

A. 'Tis manifeſt they are ſo many Idols, mere Nothings.

B. When you have look'd upon a Star or Candle with both your eyes, but one of them a little turn'd awry with your finger, has not there appeared two Stars, or two Candles? And though you call it a deception of the ſight, you cannot deny but there were two Images of the Object.

A. 'Tis true, and obſerved by all men. And the ſame I ſay of our faces ſeen in Looking-glaſſes, and of all Dreams, and of all Apparitions of dead mens Ghoſts; and wonder, ſince 'tis ſo manifeſt, I never thought upon't before, for it is a very happy encounter, and ſuch as being

being by every body well underſtood, would utterly deſtroy both Idolatry and Superſtition, and defeat abundance of Knaves that cheat and trouble the world with their devices.

B. But you muſt not hence conclude that whoſoever tells his Dream, or ſometimes takes his direction from it, is therefore an Idolater, or Superſtitious, or a Cheater. For God doth often admoniſh men by Dreams of what they ought to do; yet men muſt be wary in this caſe that they truſt not Dreams with the conduct of their lives further than by the Laws of their Country is allow'd: For you know what God ſays, Deut. 13. *If a Prophet or a Dreamer of Dreams give thee a ſigne or a wonder, and the ſigne come to paſs, yet if he bid thee ſerve other Gods, let him be put to death.* Here by ſerving other Gods (ſince they had choſen God for their King) we are to underſtand revolting from their King, or diſobeying of his Laws. Otherwiſe I ſee no Idolatry nor Superſtition in following a Dream, as many of the Patriarches (in the Old Teſtament) and of the Saints (in the New Teſtament) did.

A. Yes: Their own Dreams. But when another man ſhall dream, or ſay that he has dream'd, and require me to follow that, he muſt pardon me if I aſk him by what Authority, eſpecially if he look I ſhould pay him for it.

B. But if commanded by the Laws you live under,

under, you ought to follow it. But when there proceed from one Sound divers Echoes, what are those Echoes? And when with fingers cross'd you touch a small Bullet, and think it two; and when the same Herb or Flower smells well to one and ill to another, and the same at several times, well and ill to your self, and the like of Tastes, what are those Echoes, Feelings, Odours, and Tastes?

A. 'Tis manifest they are all but Fancies. But certainly when the Sun seems to my eye no bigger than a Dish, there is behinde it somewhere somewhat else (I suppose a real Sun) which creates those fancies, by working (one way or other) upon my eyes, and other Organs of my Senses, to cause that diversity of Fancy.

B. You say right; and that is it I mean by the word Body, which briefly I define to be any thing that hath a Being in it self, without the help of Sense.

A. Aristotle (I think) meaneth by Body, *Substance*, or *Subjectum*, wherein Colour, Sound, and other Fancies are (as he says) inherent. For the word Essence has no affinity with *Substance*. And *Seneca* says, he understands it not. And no wonder: for Essence is no part of the Language of mankinde, but a word devised by Philosophers out of the Copulation of two names, as if a man having two Hounds would make a third (if 'twere need) of their Couples.

B. 'Tis

B. 'Tis just so. For having said in themselves (for example) *A Tree is a Plant*, and conceiving well enough what is the signification of those Names, knew not what to make of the word *Is* that couples those Names; not daring to call it a Body, they called it by a new name, (derived from the word *est*) *Essentia*, and *Substantia*; deceived by the Idiome of their own Language. For in many other Tongues, and namely in the *Hebrew*, there is no such Copulative. They thought the Names of things sufficiently connected, when they are placed in their natural consequence; and were therefore never troubled with Essences, nor other Fallacy from the Copulative *Est*.

Cap. II.

Of the Principles and Method of Natural Philosophy.

A. THis History of the old Philosophers has not put me out of love, but out of hope of Philosophy from any of their Writings. I would therefore try if I could attain any knowledge therein by my own meditation: But I know neither where to begin, nor which way to proceed.

B. Your desire (you say) is to know the Causes

Cauſes of the Effects or *Phænomena* of Nature; and you confeſs they are Fancies, and (conſequently) that they are in your ſelf; ſo that the Cauſes you ſeek for onely are without you, and now you would know how thoſe external Bodies work upon you to produce thoſe *Phænomena*. The beginning therefore of your enquiry ought to be at *What it is you call a Cauſe*, I mean an *Efficient Cauſe:* For the Philoſophers make four kindes of Cauſes, whereof the *Efficient* is one. Another they call the Formal Cauſe, or ſimply the form or eſſence of the thing cauſed; as when they ſay, Four equal Angles and four equal Sides are the Cauſe of a Square Figure, or that Heavineſs is the Cauſe that makes heavie Bodies to deſcend. But that's not the Cauſe you ſeek for, nor any thing but this: *It deſcends becauſe it deſcends.* The third is the Material Cauſe, as when they ſay, The Walls and Roof, *&c.* of a houſe, are the cauſe of a Houſe. The fourth is the Final Cauſe, and hath place onely in Moral Philoſophy.

A. We will think of Final Cauſes upon ſome other occaſion; of Formal and Material not at all: I ſeek onely the Efficient, and how it acteth from the beginning to the production of the Effect.

B. I ſay then, that in the firſt place you are to enquire diligently into the nature of Motion. For the variations of Fancies, or (which

is the ſame thing) of the *Phænomena* of Nature, have all of them one Univerſal Efficient Cauſe, namely the variety of Motion. For if all things in the world were abſolutely at reſt, there could be no variety of Fancy, but living Creatures would be without ſenſe of all Objects, which is little leſs than to be dead.

A. What if a Childe new taken from the Womb ſhould with open eyes be expoſed to the Azure-Sky, do not you think it would have ſome ſenſe of the Light, but that all would ſeem unto him Darkneſs?

B. Truly, if he had no memory of any thing formerly ſeen, or by any other ſenſe perceived (which is my ſuppoſition) I think he would be in the dark. For Darkneſs is Darkneſs, whether it be black or blue, to him that cannot diſtinguiſh.

A. Howſoever that be, it is evident enough that whatſoever worketh is moved: for Action is Motion.

B. Having well conſidered the nature of Motion, you muſt thence take your Principles for the foundation and beginning of your Enquiry.

A. As how?

B. Explain as fully and as briefly as you can what you conſtantly mean by Motion; which will ſave your ſelf as well as others from being ſeduced by Æquivocation.

A. Then I ſay, Motion is nothing but change of

of place: For all the Effect of a Body upon the Organs of our Senſes is nothing but Fancy. Therefore we can fancy nothing from ſeeing it moved, but change of place.

B. 'Tis right. But you muſt then tell me alſo what you underſtand by *Place*: For all men are not yet agreed on that.

A. Well then; ſeeing we fancy a Body, we cannot but fancy it ſomewhere. And therefore I think Place is the fancy of *Here* or *There*.

B. That is not enough. *Here* and *There* are not underſtood by any but your ſelf, except you point towards it. But pointing is no part of a Definition. Beſides, though it help him to finde the Place, it will never bring him to it.

A. But ſeeing Senſe is Fancy, when we fancy a Body, we fancy alſo the Figure of it, and the ſpace it fills up. And then I may define Place to be *The preciſe ſpace within which the Body is contained.* For *Space* is alſo part of the Image we have of the Object ſeen.

B. And how define you Time?

A. As Place is to a Body, ſo (I think) is Time to the Motion of it; and conſequently I take *Time* to be our fancy or Image of the Motion. But is there any neceſſity of ſo much niceneſs?

B. Yes. The want of it is the greateſt, if not the onely cauſe, of all the diſcord amongſt Philoſophers, as may eaſily be perceived by

their abuſing and confounding the names of things that differ in their nature; as you ſhall ſee when there is occaſion to recite ſome of the Tenets of divers Philoſophers.

A. I will avoid Æquivocation as much as I can. And for the nature of Motion, I ſuppoſe I underſtand it by the Definition. What is next to be done?

B. You are to draw from theſe Definitions, and from whatſoever Truth elſe you know by the light of Nature, ſuch general Conſequences as may ſerve for Axiomes, or Principles of your Ratiocination.

A. That is hard to do.

B. I will draw them my ſelf, as many as for our preſent diſcourſe of Natural Cauſes we ſhall have need of; ſo that your part will be no more than to take heed I do not deceive you.

A. I will look to that.

B. My firſt Axiome then ſhall be this: *Two Bodies, at the ſame Time, cannot be in one Place.*

A. That's true: For we number Bodies as we fancy them diſtinct, and diſtinguiſh them by their Places. You may therefore adde, *Nor one Body at the ſame time in two Places.* And Philoſophers mean the ſame, when they ſay, *There is no penetration of Bodies.*

B. But they underſtand not their own words: For penetration ſignifies it not.

My

My ſecond Axiome is, That *nothing can begin, change, or put an end to its own Motion.* For ſuppoſing it begin juſt now, or being now in Motion, change its Way or Stop; I require the Cauſe why *now* rather than *before* or *after*, having all that is neceſſary to ſuch Motion, Change, or Reſt, alike at all times.

A. I do not doubt but the Argument is good in Bodies inanimate; but perhaps in Voluntary Agents it does not hold.

B. How it holds in Voluntary Agents we will then conſider when our Method hath brought us to the Powers and Paſſions of the minde.

A third Axiome ſhall be this: *Whatſoever Body being at Reſt is afterwards moved, hath for its Immediate Movent ſome other Body which is in Motion and toucheth it.* For, ſince nothing can move it ſelf, the Movent muſt be external. And becauſe Motion is change of place, the Movent muſt put it from its place, which it cannot do till it touch it.

A. That is manifeſt, and that it muſt more than touch it, it muſt alſo follow it. And if more parts of the Body are moved than are by the Movent touched, the Movent is not Immediate. And by this reaſon, a continued Body though never ſo great, if the firſt Superficies be preſt never ſo little back, the Motion will proceed through it.

B. Do you think that to be impoſſible? I

will prove it from your own words: For you ſay that the Movent does then touch the Body which it moveth. Therefore it puts it back; But that which is put back, puts back the next behinde, and that again the next; and ſo onward to any diſtance, the body being continued. The ſame is alſo manifeſt by experience, ſeeing one that walks with a Staff can diſtinguiſh (though blinde) between Stone and Glaſs; which were impoſſible, if the parts of his Staff between the ground and his hand made no reſiſtance. So alſo he that in the ſilence of the night lays his Ear to the ground, ſhall hear the treading of mens feet further than if he ſtood upright.

A. This is certainly true of a Staff or other hard Body, becauſe it keeps the Motion in a ſtraight Line from diffuſion. But in ſuch a Fluid Body as the Air, which being put back muſt fill an Orb, and the further it is put back, the greater Orb, the Motion will decreaſe, and in time, by the reſiſtance of Air to Air, come to an end.

B. That any Body in the world is abſolutely at Reſt, I think not true: But I grant, that in a ſpace filled every where with Body, though never ſo Fluid, if you give Motion to any part thereof, that Motion will by reſiſtance of the parts moved, grow leſs and leſs, and at laſt ceaſe; but if you ſuppoſe the ſpace utterly void, and nothing in it, then whatſoever is

once

once moved ſhall go on eternally: Or elſe that which you have granted is not true, *viz. That nothing can put an end to its own Motion.*

A. But what mean you by reſiſtance?

B. Reſiſtance is *the Motion of a Body in a way wholly or partly contrary to the way of its Movent, and thereby repelling or retarding it.* As when a man runs ſwiftly, he ſhall feel the Motion of the Air in his face. But when two hard Bodies meet, much more may you ſee how they abate each others Motion, and rebound from one another. For in a ſpace already full, the Movent cannot, in an inſtant, be communicated through the whole depth of the Body that is to be moved.

A. What other Definitions have I need of?

B. In all Motion, as in all Quantity, you muſt take the beginning of your reckoning from the leaſt ſuppoſed Motion. And this I call the *firſt Endeavour of the Movent*; which *Endeavour*, how weak ſoever, is alſo Motion. For if it have no Effect at all, neither will it do any thing though doubled, trebled, or by what number ſoever multiplied: For Nothing, though multiplied, is ſtill Nothing. Other Axiomes and Definitions we will take in, as we need them, by the way.

A. Is this all the preparation I am to make?

B. No, you are to conſider alſo the ſeveral kinds and properties of Motion, *viz.* when a

Body being moved by one or more Movents at once, in what way it is carried, ſtraight, circular, or otherwiſe crooked; and what degree of ſwiftneſs; as alſo the action of the Movent, whether Truſion, Vection, Percuſſion, Reflexion, or Refraction; and further you muſt furniſh your ſelf with as many experiments (which they call *Phænomenon*) as you can. And ſuppoſing ſome Motion for the Cauſe of your *Phænomenon*, try if by evident Conſequence, without contradiction to any other manifeſt truth or experiment, you can derive the Cauſe you ſeek for from your Suppoſition. If you can, 'tis all that is expected (as to that one Queſtion) from Philoſophy. For there is no Effect in Nature which the Author of Nature cannot bring to paſs by more ways than one.

A. What I want of Experiments you may ſupply out of your own ſtore, or ſuch Natural Hiſtory as you know to be true; though I can be well content with the knowledge of the Cauſes of thoſe things which every Body ſees commonly produced. Let us therefore now enquire the Cauſe of ſome Effect particular.

B. We will begin with that which is the moſt univerſal, the Univerſe, and enquire in the firſt place, if any place be abſolutely *empty*, that is to ſay in the language of Philoſophers, whether there be any *Vacuum* in Nature.

Cap. III.

Of Vacuum.

A. 'Tis hard to ſuppoſe, and harder to believe that the Infinite and Omnipotent Creator of all things ſhould make a work ſo vaſt as is the world we ſee, and leave a few little ſpaces with nothing at all in them; which put altogether in reſpect of the whole Creature, would be inſenſible.

B. Why ſay you that? Do you think any Argument can be drawn from it to prove there is *Vacuum*?

A. Why not? For in ſo great an Agitation of Natural Bodies, may not ſome ſmall parts of them be caſt out, and leave the places empty from whence they were thrown?

B. Becauſe he that created them is not a Fancy, but the moſt real ſubſtance that is; who being Infinite, there can be no place empty where he is, nor full where he is not.

A. 'Tis hard to anſwer this Argument, becauſe I do not remember that there is any Argument for the maintenance of *Vacuum* in the writings of Divines: Therefore I will quit that Argument, and come to another. If you take a Glaſs Vial with a narrow neck, and having

ving ſuckt it, dip it preſently at the neck into a baſon of water, you ſhall manifeſtly ſee the water riſe into the Vial. Is not this a certain ſigne that you had ſuckt out ſome of the Air, and conſequently that ſome part of the Vial was left empty?

B. No: For when I am about to ſuck, and have Air in my mouth, contracting my Cheeks I drive the ſame againſt the Air in the Glaſs, and thereby againſt every part of the ſides of the hard Glaſs. And this gives to the Air within an Endeavour outward, by which (if it be preſently dipt into the water) it will penetrate and enter into it. For Air if it be preſt will enter into any Fluid, much more into water. Therefore there ſhall riſe into the Vial ſo much water as there was Air forced into the Baſon.

A. This I confeſs is poſſible, and not improbable.

B. If ſucking would make *Vacuum*, what would become of thoſe women that are Nurſes? Should they not be in a very few days exhauſted, were it not that either the Air which is in the Childs mouth penetrateth the Milk as it deſcends, and paſſeth through it, or the Breaſt is contracted?

A. From what Experiment can you evidently infer that there is no *Vacuum*?

B. From many, and ſuch as to almoſt all men are known and familiar. If two hard Bodies,

flat and ſmooth, be joyned together in a common Superficies parallel to the Horizontal Plain, you cannot without great force pull them aſunder, if you apply your force perpendicularly to the common Superficies: But if you place that common Superficies erect to the Horizon, they will fall aſunder with their own weight. From whence I argue thus: Since their Contiguity, in what poſture ſoever, is the ſame, and that they cannot be pull'd aſunder by a perpendicular force without letting in the ambient Air in an inſtant, which is impoſſible; or almoſt in an inſtant, which is difficult: and on the other ſide, when the common Superficies is erect, the weight of the ſame hard Bodies are able to break the Contiguity, and let in the Air ſucceſſively, it is manifeſt that the difficulty of Separation proceeds from this, that neither Air nor any other Body can be moved to any (how ſmall ſoever) diſtance in an inſtant; but may eaſily be moved (the hardneſs at the ſides once maſtered) ſucceſſively. So that the Cauſe of this difficulty of Separation is this, that they cannot be parted except the Air or other matter can enter and fill the ſpace made by their diremption. And if they were infinitely hard, not at all. And hence alſo you may underſtand the Cauſe why any hard Body, when it is ſuddenly broken, is heard to crack; which is the ſwift Motion of the Air to fill the ſpace between.

Ano-

Another Experiment, and commonly known, is of a Barrel of Liquor, whoſe Tap-hole is very little, and the Bung ſo ſtopt as to admit no Air; for then the Liquor will not run: but if the Tap-hole be large it will, becauſe the Air preſt by a heavier Bodie will pierce through it into the Barrel. The like reaſon holds of a Gardeners Watering-pot, when the holes in the bottom are not too great. A third Experiment is this: Turn a thin Braſs kettle the bottom upwards, and lay it flat upon the Water. It will ſink till the water riſe within to a certain height, but no higher: Yet let the bottom be perforated, and the Kettle will be full and ſink, and the Air riſe again through the water without. But if a Bell were ſo laid on, it would be fill'd and ſink, though it were not perforated, becauſe the weight is greater than the weight of the ſame bulk of water.

A. By theſe Experiments, without any more, I am convinced, that there is not actually in Nature any *Vacuum*; but I am not ſure but that there may be made ſome little place empty, and this from two Experiments, one whereof is *Torricellius* his Experiment, which is this: Take a Cylinder of Glaſs, hollow throughout, but cloſe at the end, in form of a Sack.

B. How long?

A. As long as you will, ſo it be more than 29 inches.

B. And

B. And how broad?

A. As broad as you will, ſo it be broad enough to pour into it Quickſilver. And fill it with Quickſilver, and ſtop up the Entrance with your finger, ſo as to unſtop it again at your pleaſure. Then ſet down a Baſon, or (if you will) a Sea of Quickſilver, and inverting the Cylinder full as it is, dip the end into the Quickſilver, and remove your finger, that the Cylinder may empt it ſelf. Do you conceive me? For there is ſo many paſſing by, that I cannot paint it.

B. Yes, I conceive you well enough. What follows?

A. The Quickſilver will deſcend in the Cylinder, not till it be level with that in the Baſon according to the nature of heavie Fluids, but ſtay and ſtand above it at the height of 29 inches or very neer it, the bottom being now uppermoſt that no Air can get in.

B. What do you infer from this?

A. That all the Cavitie above 29 inches is fill'd with *Vacuum*.

B. 'Tis very ſtrange that I, from this ſame Experiment, ſhould infer (and I think evidently) that it is fill'd with Air. I pray, tell me, when you had inverted the Cylinder, full as it was, and ſtopt with your finger, dipt into the Baſon, if you had then removed your finger, whether you think the Quickſilver would not all have fallen out?

A. No

A. No ſure. The Air would have been preſt upward through the Quickſilver it ſelf: For a man with his hand can eaſily thruſt a Bladder of Air to the bottom of a Baſon of Quickſilver.

B. It is therefore manifeſt that Quickſilver can preſs the Air through the ſame Quickſilver.

A. 'Tis manifeſt; and alſo it ſelf riſe into the Air.

B. What cauſe then can there be, why it ſhould ſtand ſtill at 29 inches above the level of the Baſon, rather than any place elſe?

A. 'Tis not hard to aſſigne the cauſe of that. For ſo much Quickſilver as was above the 29 inches, will raiſe the firſt level of that in the baſon, as much as if you had pour'd it on; and thereby bring it to an Æquilibrium. So that I ſee plainly now, that there is no neceſſity of *Vacuum* from this Experiment. For I conſidered onely that naturally Quickſilver cannot aſcend in Air, nor Air deſcend in Quickſilver, though by force it may.

B. Nor do I think that *Torricellius* or any other Vacuiſt thought of it more than you. But what is the ſecond Experiment?

A. There is a Sphere of Glaſs, which they call a Recipient, of the Capacity of three or four Gallons. And there is inſerted into it the end of a hollow Cylinder of Braſs above a foot long; ſo that the whole is one Veſſel,

and

and the bore of the Cylinder three inches Diameter. Into which is thruſt by force a ſolid Cylinder of Wood, covered with leather ſo juſt, as it may in every point exactly touch the Concave Superficies of the Braſs. There is alſo to let out the Air which the wooden Cylinder as it enters (called the Sucker) drives before it, a Flap to keep out the External Air while they are pulling the Sucker. Beſides, at the top of the Recipient there is a hole to put into it any thing for Experiment. The Sucker being now forc'd up into the Cylinder, what do you think muſt follow?

B. I think it will require as much ſtrength to pull it back, as it did to force it in.

A. That is not it I aſk, but what would happen to the Recipient.

B. I think ſo much Air as would fill the place the Sucker leaves, would deſcend into it out of the Recipient; and alſo that juſt ſo much from the External Air would enter into the Recipient, between the Braſs and the Wood, at firſt very ſwiftly, but, as the place increaſed, more leaſurely.

A. Why may not ſo much Air rather deſcend into the place forſaken, and leave as much *Vacuum* as that comes to, in the Recipient? For otherwiſe no Air will be pumpt out; nor can that wooden Peſtle be called a Sucker.

B. That's it I ſay. There is no Air either pumpt or ſucked out.

A. How

A. How can the Air pass between the Leather and the Brass, or between the Leather and the Wood being so exactly contiguous, or through the Leather it self?

B. I conceive no such exact contiguity, nor such fastness of the Leather: For I never yet had any that in a storm would keep out either Air or Water.

A. But how then could there be made in the Recipient such strange alteration both on animate and inanimate Bodies?

B. I will tell you how: The Air descends out of the Recipient, because the Air which the Sucker removeth from behinde it self as it is pulling out, has no place to retire into without. And therefore is driven into the Engine between the wood of the Sucker and the brass of the Cylinder, and causes as much Air to come into the place forsaken by the retiring Sucker; which causeth by oft repetition of the force, a violent circulation of the Air within the Recipient, which is able quickly to kill any thing that lives by respiration, and make all the alterations that have appeared in the Engine.

CAP.

Cap. IV.

Of the Syſteme of the World.

B. YOu are come in good time; let us therefore ſit down. There is Ink, Paper, Ruler, and Compaſs. Draw a little Circle to repreſent the Body of the Sun. Fig. 1.

A. 'Tis done. The Centre is A, the Circumference is L M.

B. Upon the ſame Centre A, draw a larger Circle to ſtand for the Ecliptick: For you know the Sun is always in the Plain of the Ecliptick.

A. There 'tis. The Diameters of it at right Angles are B Z.

B. Draw the Diameter of the Æquator.

A. How?

B. Through the Centre A (for the Earth is alſo always in the Plain of the Æquator or of ſome of its Parallels) ſo as to be diſtant from B 23 *deg.* and a half.

A. Let it be H I: And let C G be equal to B H; and ſo G will be one of the Poles of the Ecliptick, ſuppoſe the North-Pole; and then H will be Eaſt, and I Weſt. And C A produced to the Circumference in E, makes E the South-Pole.

B. Take

B. Take C K equal to C G, and the Chord G K will be the Diameter of the Arctick-Circle, and parallel to H I, the Diameter of the Æquator. Laſtly, upon the point B, draw a little Circle wherein I ſuppoſe to be the Globe of the Earth.

A. 'Tis drawn, and marked with *l m*. And B D and K G joyned will be parallel; and as H and I are Eaſt and Weſt, and ſo are B and D, and G and K.

B. True; but producing Z B to the Circumference *l m* in *b*, the Line B *b* will be in the Diameter of the Ecliptick of the Earth, and B *m* in the Diameter of the Æquator of the Earth. In like manner, if you produce K G cutting the Circle, whoſe Centre is G, in *d* and *e*, and make an Angle *n* G *d* equal to *b* B *m*, the Line *n* G will be in the Ecliptick of the Earth, becauſe G *d* is in the Æquator of the Earth. So that in the Annual Motion of the Earth through the Ecliptick, every ſtreight Line drawn in the Earth, is perpetually kept parallel to the place from whence it is removed.

A. 'Tis true; and 'tis the Doctrine of *Copernicus*. But I cannot yet conceive by what one Motion this Circle can be deſcribed otherwiſe than we are taught by *Euclid*. And then I am ſure that all the Diameters ſhall croſs one another in the Centre, which in this Figure is A.

B. I do not ſay that the Diameters of a Sphere or Circle can be parallel; but that if a Circle of a leſſer Sphere be moved upon the Circumference of a great Circle of a greater Sphere, that the ſtreight Lines that are in the leſſer Sphere may be kept parallel perpetually to the places they proceed from.

A. How? And by what Motion?

B. Take into your hand any ſtreight Line, (as in this Figure) the Line L A M, which we ſuppoſe to be the diameter of the Suns Body; and moving it parallelly, with the ends in the Circumference, ſo as that the end M may withal deſcribe a ſmall Circle, as M *a*. It is manifeſt that all the other points of the ſame Line L M will by the ſame Motion, at the ſame time, deſcribe equal Circles to it. Likewiſe if you take in your hand any two Diameters faſtened together, the ſame Parallel-motion of the line L M, ſhall cauſe all the points of the other Diameter to make equal Circles to the ſame M *a*.

A. 'Tis evident; as alſo that every point of the Suns body ſhall do the like. And not onely ſo, but alſo if one end deſcribe any other Figure, all the other points of the Body ſhall deſcribe like and equal Figures to it.

B. You ſee by this, that this Parallel-motion is compounded of two Motions, one Circular upon the Superficies of a Sphere, the other a ſtreight Motion from the Centre to every point of the ſame Superficies, and beyond it.

A. I ſee it.

B. It follows hence, that the Sun by this Motion muſt every way repel the Air; and ſince there is no empty place for retiring, the Air muſt turn about in a Circular ſtream; but ſlower or ſwifter according as it is more or leſs remote from the Sun, and that according to the nature of Fluids, the Particles of the Air muſt continually change place with one another; and alſo that the ſtream of the Air ſhall be the contrary way to that of the Motion, for elſe the Air cannot be repelled.

A. All this is certain.

B. Well. Then if you ſuppoſe the Globe of the Earth to be in this ſtream which is made by the Motion of the Suns Body from Eaſt to Weſt, the ſtream of Air wherein is the Earths Annual Motion will be from Weſt to Eaſt.

A. 'Tis certain.

B. Well. Then if you ſuppoſe the Globe of the Earth, whoſe Circle is moved Annually, to be *l m*, the ſtream of the Air without the Ecliptick falling upon the Superficies of the Earth *l m* without the Ecliptick, being ſlower, and the ſtream that falleth within ſwifter, the Earth ſhall be turned upon its own Centre proportionally to the greatneſs of the Circles; and conſequently their Diameters ſhall be parallel; as alſo are other ſtreight Lines correſpondent.

A. I deny not but the ſtreams are as you ſay;

ſay; and confeſs that the proportion of the ſwiftneſs without, is to the ſwiftneſs within, as the Suns Ecliptick to the Ecliptick of the Earth; that is to ſay, as the Angle H A B to the Angle *m* B *b*. And I like your Argument the better, becauſe it is drawn from *Copernicus* his foundation. I mean the compounded Motion of Streight and Circular.

B. I think I ſhall not offer you many demonſtrations of Phyſical concluſions that are not derived from the Motions ſuppoſed or proved by *Copernicus*. For thoſe Concluſions in Natural Philoſophy I moſt ſuſpect of falſhood, which require moſt variety of Suppoſitions for their demonſtrations.

A. The next thing I would know, is how great or little you ſuppoſe that Circle *a* M.

B. I ſuppoſe it leſs than you can make it: For there appears in the Sun no ſuch Motion ſenſible. 'Tis the firſt Endeavour of the Suns Motion. But for all that, as ſmall as the Circle is, the Motion may be as ſwift, and of as great ſtrength as 'tis poſſible to be named. 'Tis but a kinde of trembling that neceſſarily happeneth in thoſe Bodies, which with great reſiſtance preſs upon one another.

A. I underſtand now from what Cauſe proceedeth the Annual Motion. Is the Sun the Cauſe alſo of the Diurnal Motion?

B. Not the immediate Cauſe. For the Diurnal Motion of the Earth is upon its own

Centre, and therefore the Suns Motion cannot deſcribe it. But it proceedeth as a neceſſary conſequence from the Annual Motion. For which I have both experience and demonſtration. The Experiment is this: Into a large Hemiſphere of Wood, ſpherically Concave, put in a Globe of Lead, and with your hands hold it faſt by the brim, moving your hands circularly, but in a very ſmall compaſs, you ſhall ſee the Globe circulate about the Concave Veſſel, juſt in the ſame manner as the Earth doth every year in the Air; and you ſhall ſee withal, that as it goes, it turns perpetually upon its own Centre, and very ſwiftly.

A. I have ſeen it: And 'tis uſed in ſome great Kitchins to grinde Muſtard.

B. Is it ſo? Therefore take a Hemiſphere of Gold (if you have it) the greater the better, and a Bullet of Gold, (and without Muſtard) you ſhall ſee the ſame Effect.

A. I doubt it not. But the of it Cauſe is evident. For any Spherical Body being in Motion upon the ſides of a Concave and hard Sphere, is all the way turned upon its own Centre by the reſiſtance of the hard Wood or Metal. But the Earth is a Bullet without weight, and meeteth onely with Air, without any harder body in the way to reſiſt it.

B. Do you think the Air makes no reſiſtance, eſpecially to ſo ſwift a Motion as is the Annual Motion of the Earth? If it do make

make any reſiſtance, you cannot doubt but that it ſhall turn the Earth circularly, and in a contrary way to its Annual Motion; that is to ſay, from Eaſt to Weſt, becauſe the Annual Motion is from Weſt to Eaſt.

A. I confeſs it. But what deduce you from theſe Motions of the Sun?

B. I deduce (firſt) that the Air muſt of neceſſity be moved both circularly about the Body of the Sun according to the Ecliptick, and alſo every way directly from it. For the Motion of the Suns Body is compounded of this Circular Motion upon the Sphere L M, and of the ſtreight motion of its Semi-diameters from the Centre A to the Superficies of the Suns Body, which is L M. And therefore the Air muſt needs be repelled every way, and alſo continually change place to fill up the places forſaken by other parts of the Air, which elſe would be empty, there being no *Vacuum* to retire unto. So that there would be a perpetual ſtream of Air, and in a contrary way to the Motion of the Suns Body, ſuch as is the Motion of Water by the ſides of a Ship under ſail.

A. But this Motion of the Earth from Weſt to Eaſt, is onely Circular, ſuch as is deſcribed by a Compaſs about a Centre; and cannot therefore repel the Air as the Sun does. And the Diſciples of *Copernicus* will have it to be the Cauſe of the Moons monthly motion about the Earth.

 B. And

B. And I think *Copernicus* himſelf would have ſaid the ſame, if his purpoſe had been to have ſhewn the Natural Cauſes of the Motions of the Stars. But that was no part of his deſigne; which was onely from his own obſervations, and thoſe of former Aſtronomers, to compute the times of their Motions; partly to foretel the Conjunctions, Oppoſitions, and other Aſpects of the Planets; and partly to regulate the times of the Churches Feſtivals. But his followers, *Kepler* and *Galileo*, make the Earths Motion to be the Efficient Cauſe of the Monthly motion of the Moon about the Earth; which without the like Motion to that of the Sun in L M, is impoſſible. Let us therefore for the preſent take it in as a neceſſary Hypotheſis; which from ſome Experiment that I ſhall produce in our following diſcourſes, may prove to be a certain truth.

A. But ſeeing A is the Centre both of the Suns Body and of the Annual Motion of the Earth, How can it be (as all Aſtronomers ſay it is) that the Orb of the Annual Motion of the Earth ſhould be Excentrique to the Suns Body? For you know that from the Vernal Æquinox to the Autumnal, there be 187 days; but from the Autumnal Æquinox to the Vernal, there be but 178 days. What Natural Cauſe can you aſſigne for this Excentricity?

B. Kepler aſcribes it to a Magnetique vertue, *viz.* that one part of the Earths Superficies has

a

a greater kindneſs for the Sun than the other part.

A. I am not ſatisfied with that. It is Magical rather than Natural, and unworthy of *Kepler*. Tell me your own opinion of it.

B. I think that the Magnetical vertue he ſpeaks of, conſiſteth in this: that the Southern Hemiſphere of the Earth is for the greateſt part Sea, and that the greateſt part of the Northern Hemiſphere is dry Land. But how it is poſſible that from thence ſhould proceed the Excentricity (the Sun being neereſt to the Earth, when he is in the Winter-Solſtice) I ſhall ſhew you when we come to ſpeak of the Motions of Air and Water.

A. That's time enough: For I intend it for our next meeting. In the mean time I pray you tell me what you think to be the Cauſe why the Equinoctial (and conſequently the Solſtitial) points are not always in one and the ſame point of the Ecliptique of the Fixt Stars. I know they are not, becauſe the Sun does not riſe and ſet in points diametrally oppoſite: For if it did, there would be no difference of the Seaſons of the year.

B. The cauſe of that can be no other, than that the Earth (which is *l m*) hath the like Motion to that which I ſuppoſe the Sun to have in L M, compounded of ſtreight and circular from Weſt to Eaſt in a day, as the Annual Motion hath in a year; ſo that (not

reckoning the Excentricity) it will be moved through the Ecliptiques one Revolution (as *Copernicus* proveth) about one degree. Suppoſe then the whole Earth moved from H to I, (which is half the year) circularly, but falling from I to *i* in the ſame time about 30 minutes, and as much in the other Hemiſphere from H to *k*; then draw the line *i k*, which will be equal and parallel to H I, and be the Diameter of the Æquator for the next year. But it ſhall not cut the Diameter of the Ecliptick B ♑ in A, which was the Equinoctial of the former year, but in *o* 36 ſeconds from the firſt degree of *Aries*. Suppoſe the ſame done in the Hemiſphere under the Plain of the paper, and ſo you have the double of 36 ſeconds, that is 72 ſeconds, or very neer, for the progreſs of the Vernal Equinox in a year. The cauſe why I ſuppoſe the Arch I *i* to be half a degree in the Ecliptique of the Earth, is, that *Copernicus* and other Aſtronomers, and Experience, agree in this, that the Æquinoctial points proceed according to the order of the Signes, *Aries*, *Taurus*, *Gemini*, &c. from Weſt to Eaſt every 100 year one degree or very neer.

A. In what time do they make the whole Revolution through the Ecliptique of the Sky?

B. That you may reckon. For we know by Experience that it hath proceeded about one degree, that is 60 minutes conſtantly a long

long time in a hundred years. But as 100 years to one degree, ſo is 36000 years to 360 degrees. Alſo as 100 years to one degree, ſo is one year to the hundred part of one degree or 60 minutes; which is $\frac{60}{100}$, or 36 ſeconds for the progreſs of one year; which muſt be ſomewhat more than a degree according to *Copernicus*, who, *lib.* 3. *cap.* 2. ſaith, That for 400 years before *Ptolomie* it was one degree almoſt conſtantly. Which is well enough as to the Natural Cauſe of the Preceſſion of the Æquinoctial points, which is the often-ſaid compounded Motion, though not an exact Aſtronomical Calculation.

A. And 'tis a great ſigne that his Suppoſition is true. But what is the Cauſe that the Obliquity of the Ecliptique, that is, the diſtance between the Æquinoctial and the Solſtice, is not always the ſame?

B. The neceſſity of the Obliquity of the Ecliptique is but a conſequence to the Preceſſion of the Æquinoctial points. And therefore if from C the North-Pole you make a little Circle C *u* equal to 15 minutes of a degree upon the Earth, and another *u s* equal to the ſame, which will appear like this Figure 8, that is (as *Copernicus* calls it) a Circle twined, the Pole C will be moved half the time of the Æquinoctial points, in the arc C *u*, and as much in the alternate arc *u s* deſcending to *s*. But in the arc *s u*, and its alternate riſing to C. The

cauſe

cauſe of the twining is the Earths Annual Motion the ſame way in the Ecliptique, and makes the four quarters of it; and makes alſo their revolution twice as ſlow as that of the Æquinoctial points. And therefore the Motion of it is the ſame compounded Motion which *Copernicus* takes for his Suppoſition, and is the cauſe of the Preceſſion of the Æquinoctial points, and conſequently of the variation of the Obliquity, adding to it or taking from it ſomewhere more, ſomewhere leſs; ſo as that one with another the addition is not much more, nor the ſubſtraction much leſs than 30 minutes. But as for the Natural Efficient cauſe of this compounded Motion, either in the Sun, or the Earth, or any other Natural Body, it can be none but the immediate hand of the Creator.

A. By this it ſeems that the Poles of the Earth are always the ſame, but make this 8 in the Sphere of the fixt Stars neer that which is called *Cynoſura*.

B. No: 'Tis deſcribed on the Earth, but the Annual Motion deſcribes a Circle in the Sphere of the fixed Stars. Though I think it improper to ſay a Sphere of the fixt Stars, when 'tis ſo unlikely that all the fixt Stars ſhould be in the Superficies of one and the ſame Globe.

A. I do not believe they are.

B. Nor I, ſince they may ſeem leſs one than another, as well by their different diſtances, as by

by their different magnitudes. Nor is it likely that the Sun (which is a fixt Star) is the Efficient Cauſe of the Motion of thoſe remoter Planets, *Mars*, *Jupiter*, and *Saturn*; ſeeing the whole Sphere, whoſe Diameter is the diſtance between the Sun and the Earth, is but a point in reſpect of the diſtance between the Sun and any other fixed Star. Which I ſay onely to excite thoſe that value the knowledge of the Cauſe of Comets, to look for it in the Dominion of ſome other Sun than that which moveth the Earth. For why may not there be ſome other fixed Star, neerer to ſome Planet than is the Sun, and cauſe ſuch a light in it as we call a Comet?

A. As how?

B. You have ſeen how in high and thin Clouds above the Earth, the Sun-beams piercing them have appeared like a Beard; and why might not ſuch a Beard have appeared to you like a Comet, if you had lookt upon it from as high as ſome of the fixed Stars?

A. But becauſe it is a thing impoſſible for me to know, I will proceed in my own way of enquiry. And ſeeing you aſcribe this compounded Motion to the Sun and Earth, I would grant you that the Earth (whoſe Annual Motion is from Weſt to Eaſt) ſhall give the Moon her Monthly-motion from Eaſt to Weſt. But then I aſk you whether the Moon have alſo that compounded Motion of the Earth, and

with

with it a Motion upon its own Centre, as hath the Earth? For ſeeing the Moon has no other Planet to carry about her, ſhe needs it not.

B. I ſee reaſon enough, and ſome neceſſity, that the Moon ſhould have both thoſe Motions. For you cannot think that the Creator of the Stars, when he gave them their Circular Motion, did firſt take a Centre, and then deſcribe a Circle with a Chain or Compaſs, as men do? No; he moved all the parts of a Star together and equally in the Creation: And that's the reaſon I give you. The neceſſity of it, comes from this *Phænomenon*, that the Moon doth turn one and the ſame face towards the Earth: Which cannot be by being moved about the Earth parallelly, unleſs alſo it turn about its own Centre. Beſides, we know by experience, that the Motion of the Moon doth adde not a little to the Motion of the Sea: Which were impoſſible if it did not adde to the Stream of the Air, and by conſequence to that of the Water.

A. If you could get a piece of the true and intimate Subſtance of the Earth, of the bigneſs of a Muſquet-bullet, do you believe that the Bullet would have the like compounded Motion to that which you attribute to the Sun, Earth, and Moon?

B. Yes truly; but with leſs ſtrength, according to its magnitude; ſaving that by its Gra-

Gravity falling to the Earth, the activity of it would be unperceived.

A. I will trouble you no more with the Nature of Celeſtial appearances. But I pray you tell me by what art a man may finde what part of a Circle the Diameter of the Suns Body doth ſubtend in the Ecliptique Circle.

B. Kepler ſays it ſubtends 30 minutes, which is half a degree. His way to finde it is by letting in the Sun-beams into a cloſe room through a ſmall hole, and receiving the image of it upon a plain perpendicularly. For by this means he hath a Triangle, whoſe ſides and angles he can know by meaſure; and the vertical Angle he ſeeks for, and the ſubſtance of the arc of the Suns Body.

A. But I think it impoſſible to diſtinguiſh where the part illuminate toucheth the part not illuminate.

B. Another way is this: Upon the Æquinoctial-day, with a Watch that ſhews the minutes ſtanding by you, obſerve when the lower brim of the Suns ſetting firſt comes to the Horizon, and ſet the Index to ſome minute of the Watch; and obſerve again the upper brim when it comes to the Horizon: then count the minutes, and you have what you look for. Other way I know none.

Cap. V.

Of the Motions of Water and Air.

A. I Have conſidered, as you bad me, this compounded Motion with great admiration. Firſt, it is that which makes the difference between *Continuum* and *Contiguum*, which till now I never could diſtinguiſh. For Bodies that are but Contiguous, with any little force are parted; but by this compounded Motion (becauſe every point of the body makes an equal Line in equal time, and every Line croſſes all the reſt) one part cannot be ſeparated from another, without diſturbing the Motion of all the other parts at once. And is not that the Cauſe, think you, that ſome Bodies when they are preſt or bent, as ſoon as the force is removed, return again of themſelves to their former figure?

B. Yes ſure; ſaving that it is not of themſelves that they return, (for we were agreed that nothing can move it ſelf) but it is the Motion of the parts which are not preſt, that delivers thoſe that are. And this reſtitution the Learned now call the *Spring* of a Body. The *Greeks* called it *Antitypia.*

A. When I conſidered this Motion in the Sun and

and the Earth and Planets, I fancied them as ſo many Bodies of the Army of the Almighty in an immenſe field of Air, marching ſwiftly, and commanded (under God) by his glorious Officer the Sun, or rather forced ſo to keep their order in every part of every of thoſe Bodies, as never to go out from the diſtance in which he had ſet them.

B. But the parts of the Air and other Fluids keep not their places ſo.

A. No. You told me that this Motion is not natural in the Air, but received from the Sun.

B. True. But ſince we ſeek the Natural Cauſes of Sublunary Effects, where ſhall we begin?

A. I would fain know what makes the Sea to ebbe and flow at certain Periods, and what cauſeth ſuch variety in the Tides.

B. Remember that the Earth turneth every day upon its own Axis from Weſt to Eaſt; and all the while it ſo turneth, every point thereof by its compounded Motion makes other Circlings, but not on the ſame Centre, which is (you know) a riſing in one part of the day, and a falling in the other part. What think you muſt happen to the Sea, which reſteth on it, and is a Fluid Body?

A. I think it muſt make the Sea riſe and fall. And the ſame happeneth alſo to the Air, from the Motion of the Sun.

B. Re-

B. Remember alſo, in what manner the Sea is ſituated in reſpect of the Dry Land.

A. Is not there a great Sea that reacheth from the Straight of *Magellan* Eaſtward to the *Indies*, and thence to the ſame Straight again? And is not there a great Sea called the *Atlantick* Sea that runneth Northward to us? and does not the great South-Sea run alſo up into the Northern Seas? But I think the *Indian* and the South-Sea of themſelves to be greater than all the reſt of the Surface of the Globe.

B. How lieth the water in thoſe two Seas?

A. Eaſt and Weſt, and riſes and falls a little, as it is forc'd to do by this compounded Motion, which is a kind of ſuccuſſion of the Earth, and fills both the *Atlantick* and Northern Seas.

B. All this would not make a viſible difference between High and Low water, becauſe this Motion being ſo regular, the unevenneſs would not be great enough to be ſeen. For though in a Baſon the water would be thrown into the Air, yet the Earth cannot throw the Sea into the Air.

A. Yes. The Baſon, if gently moved, will make the water ſo move, that you ſhall hardly ſee it riſe.

B. It may be ſo. But you ſhould never ſee it riſe as it doth, if it were not checkt. For at the Straight of *Magellan*, the great South-Sea is checkt by the ſhore of the Continent of *Peru* and

and *Chily*, and forced to riſe to a great height, and made to run up into the Northern Seas on that ſide by the coaſt of *China*; and at the return is checkt again and forced through the *Atlantick* into the *Britiſh* and *German* Seas. And this is done every day. For we have ſuppoſed that the Earths Motion in the Ecliptique cauſed by the Sun is Annual; and that its Motion in the Æquinoctial, is Diurnal. It followeth therefore from this compounded Motion of the Earth, the Sea muſt Ebb and Flow twice in the ſpace of Twenty four hours, or thereabout.

A. Has the Moon nothing to do in this buſineſs?

B. Yes. For ſhe hath alſo the like Motion. And is, though leſs ſwift, yet much neerer to the Earth. And therefore when the Sun and Moon are in Conjunction or Oppoſition, the Earth, as from two Agents at once, muſt needs have a greater Succuſſion. And if it chance at the ſame time the Moon alſo be in the Ecliptique, it will be yet greater, becauſe the Moon then worketh on the Earth leſs obliquely.

A. But when the Full or New Moon happen to be then when the Earth is in the Æquinoctial points, the Tides are greater than ordinary. Why is that?

B. Becauſe then the force by which they move the Sea, is at that time, to the force by which they move the ſame at other times,

as the Æquinoctial Circle to one of its Parallels, which is a leſſer Circle.

A. 'Tis evident. And 'tis pleaſant to ſee the Concord of ſo many and various motions, when they proceed from one and the ſame Hypotheſis. But what ſay you to the ſtupendious Tides which happen on the Coaſts of *Lincolnſhire* on the Eaſt, and in the River of *Severn* on the Weſt?

B. The cauſe of that, is their proper Scituation. For the Current of the Ocean through the *Atlantick* Sea, and the Current of the South-Sea through the Northern Seas meeting together, raiſe the water in the *Iriſh* and *Britiſh* Seas a great deal higher than ordinary. Therefore the mouth of the *Severn* being directly oppoſite to the Current from the *Atlantick* Sea, and thoſe Sands on the Coaſt of *Lincolnſhire* directly oppoſite to the Current of the *German* Sea, thoſe Tides muſt needs fall furiouſly into them, by this Succeſſion of the water.

A. Does, when the Tide runs up into a River, the water all riſe together, and fall together when it goes out?

No: One part riſeth and another falleth at the ſame time; becauſe the Motion of the Earth riſing and falling, is that which makes the Tide.

A. Have you any Experiment that ſhews it?

B. Yes.

B. Yes. You know that in the *Thames*, it is high water at *Greenwich* before it is high water at *London*-bridge. The water therefore falls at *Greenwich* whilſt it riſeth all the way to *London*. But except the top of the water went up, and the lower part downward, it were impoſſible.

A. 'Tis certain. It is ſtrange that this one Motion ſhould ſalve ſo many apparences, and ſo eaſily. But I will produce one Experiment of water, not in the Sea, but in a Glaſs. If you can ſhew me that the cauſe of it is this compounded Motion, I ſhall go neer to think it the Cauſe of all other Effects of Nature hitherto diſputed of. The Experiment is common, and deſcribed by the Lord Chancellour *Bacon*, in the third page of his Natural Hiſtory. *Take* (ſaith he) *a Glaſs of water, and draw your finger round about the lip of the Glaſs, preſſing it ſomewhat hard; after you have done ſo a few times, it will make the water frisk up into a fine Dew.* After I had read this, I tried the ſame with all diligence my ſelf, and found true not onely the friſking of the water to above an inch high, but alſo the whole Superficies to circulate, and withal to make a pleaſant ſound. The Cauſe of the friſking he attributes to a tumult of the inward parts of the Subſtance of the Glaſs ſtriving to free it ſelf from the preſſure.

B. I have tried and found both the Sound

and Motion; and do not doubt but the preſſure of the parts of the Glaſs was part of the Cauſe. But the Motion of my finger about the Glaſs was always parallel; and when it chanced to be otherwiſe, both Sound and Motion ceaſed.

A. I found the ſame. And being ſatisfied, I proceed to other queſtions. How is the water (being a heavie Body) made to aſcend in ſmall particles into the Air, and be there for a time ſuſtained in form of a Cloud, and then fall down again in Rain?

B. I have ſhewn already, that this compounded Motion of the Sun, in one part of its Circumlation, drives the Air one way, and in the other part, the contrary way; and that it cannot draw it back again, no more than he that ſets a ſtone a flying can pull it back. The Air therefore, which is contiguous to the water, being thus diſtracted, muſt either leave a *Vacuum*, or elſe ſome part of the water muſt riſe and fill the ſpaces continually forſaken by the Air. But, that there is no *Vacuum*, you have granted. Therefore the water riſeth into the Air, and maketh the Clouds; and ſeeing they are very ſmall and inviſible parts of the water, are (though naturally heavie) eaſily carried up and down with the Wind, till, meeting with ſome Mountain or other Clouds, they be preſt together into greater drops, and fall by their weight. So alſo it is forced up in moiſt

moiſt ground, and with it many ſmall Atomes of the Earth, which are either twiſted with the riſing water into Plants, or are carried up and down in the Air incertainly. But the greateſt Quantity of Water is forced up from the great South and *Indian* Seas, that lie under the Tropique of *Capricorn*. And this Climate is that which makes the Suns *Perigæum* to be always on the Winter-Solſtice. And that is the part of the Terreſtrial Globe which *Keplerus* ſays is kinde to the Sun; whereas the other part of the Globe (which is almoſt all dry land) has an Antipathy to the Sun. And ſo you ſee where this Magnetical vertue of the Earth lies. For the Globe of the Earth having no Natural Appetite to any place, may be drawn by this Motion of the Sun a little neerer to it, together with the water which it raiſeth.

A. Can you gueſs what may be the Cauſe of Wind?

B. I think it manifeſt that the unconſtant Winds proceed from the uncertain Motion of the Clouds aſcending and deſcending, or meeting with one another. For the Winds after they are generated in any place by the deſcent of a Cloud, they drive other Clouds this way and that way before them, the Air ſeeking to free it ſelf from being pent up in a ſtraight. For when a Cloud deſcendeth, it makes no wind ſenſible directly under it ſelf.

But the Air between it and the Earth is preſt and forced to move violently outward. For it is a certain Experiment of Mariners, that if the Sea go high when they are becalmed, they ſay they ſhall have more Wind than they would; and take in their Sails all but what is neceſſary for ſteering. They know (it ſeems) that the Sea is moved by the deſcent of Clouds at ſome diſtance off: Which preſſeth the water, and makes it come to them in great Waves. For a Horizontal Wind does but curl the Water.

A. From whence come the Rivers?

B. From the Rain, or from the falling of Snow on the higher ground. But when it deſcendeth under ground, the place where it again ariſeth is called the Spring.

A. How then can there be a Spring upon the top of a Hill?

B. There is no Spring upon the very top of a Hill, unleſs ſome Natural Pipe bring it thither from a higher Hill.

A. *Julius Scaliger* ſays, there is a River, and in it a Lake, upon the top of Mount *Cenis* in *Savoy*; and will therefore have the Springs to be ingendred in the Caverns of the Earth by Condenſation of the Air.

B. I wonder he ſhould ſay that. I have paſs'd over that Hill twice ſince the time I read that in *Scaliger*, and found that River as I paſs'd, and went by the ſide of it in plain ground

ground almoſt two miles. Where I ſaw the water from two great Hills, one on one ſide, the other on the other, in a thouſand ſmall Rillets of melting Snow fall down into it. Which has made me never to uſe any Experiment the which I have not my ſelf ſeen. As for the converſion of Air into Water by Condenſation, and of Water into Air by Rarefaction (though it be the doctrine of the *Peripatetiques*) it is a thing incogitable, and the words are inſignificant. For by *Denſum* is ſignified onely frequencie and cloſeneſs of parts; and by *Rarum* the contrary. As when we ſay a Town is thick with houſes, or a Wood with trees, we mean not that one houſe or tree is thicker than another, but that the ſpaces between are not ſo great. But (ſince there is no *Vacuum*) the ſpaces between the parts of Air are no larger than between the parts of Water, or of any thing elſe.

A. What think you of thoſe things which Mariners that have ſailed through the *Atlantick* Sea called *Spouts*, which pour down water enough at once to drown a great Ship?

B. 'Tis a thing I have not ſeen. And therefore can ſay nothing to it; though I doubt not but when two very large and heavie Clouds ſhall be driven together by two great and contrary winds, the thing is poſſible.

A. I think your reaſon good. And now will propound to you another Experiment.

I have ſeen an exceeding ſmall Tube of Glaſs with both ends open ſet upright in a Veſſel of Water, and that the Superficies of the Water within the Tube was higher a good deal than of that in the Veſſel; but I ſee no reaſon for it.

B. Was not part of the Glaſs under Water? Muſt not then the Water in the Veſſel riſe? Muſt not the Air that lay upon it riſe with it? Whither ſhould this riſing Air go, ſince there is no place empty to receive it? It is therefore no wonder if the Water, preſs'd by the Subſtance of the Glaſs which is dipt into it, do rather riſe into a very ſmall Pipe, than come about a longer way into the open Air.

A. 'Tis very probable. I obſerved alſo that the top of the incloſed Water was a concave Superficies; which I never ſaw in other Fluids.

B. The Water hath ſome degree of tenacity, though not ſo great but that it will yield a little to the Motion of the Air; as is manifeſt in the Bubbles of water, where the concavity is always towards the Air. And this I think the cauſe why the Air and Water meeting in the Tube make the Superficies towards the Air concave, which it cannot do to a Fluid of greater tenacity.

A. If you put into a Baſon of Water a long rag of Cloth, firſt drenched in water, and let the longer part of it hang out, it is known by Expe-

Experience, that the Water will drop out as long as there is any part of the other end under Water.

B. The cauſe of it is, that water (as I told you) hath a degree of tenacity. And therefore being continued in the rag till it be lower without than within, the weight will make it continue dropping, though not onely becauſe it is heavie (for if the rag lay higher without than within, and were made heavier by the breadth, it would not deſcend) but 'tis becauſe all heavie Bodies Naturally deſcend with proportion of ſwiftneſs duplicate to that of the time; whereof I ſhall ſay more when we talk of Gravity.

A. You ſee how deſpicable Experiments I trouble you with. But I hope you will pardon me.

B. As for mean and common Experiments, I think them a great deal better Witneſſes of Nature, than thoſe that are forced by fire, and known but to very few.

Cap. VI.

Of the Cauſes and Effects of Heat and Cold.

A. 'TIs a fine day, and pleaſant walking through the Fields, but that the Sun is a little too hot.

B. How know you that the Sun is hot?

A. I feel it.

B. That is to ſay, you know that your ſelf, but not that the Sun is hot. But when you finde your ſelf hot, what Body do you feel?

A. None.

B. How then can you infer your heat from the Senſe of Feeling? Your walking may have made you hot: Is Motion therefore hot? No. You are to conſider the Concomitants of your heat; as, that you are more faint, or more ruddy, or that you ſweat, or feel ſome Endeavour of Moiſture or Spirits tending outward; and when you have found the Cauſes of thoſe Accidents, you have found the Cauſes of Heat, which in a living Creature, and ſpecially in a Man, is many times the Motion of the parts within him, ſuch as happen in ſickneſs, anger, and other paſſions of the minde; which are not in the Sun nor in Fire.

A. That

A. That which I desire now to know, is what Motions and of what Bodies without me are the Efficient Causes of my Heat.

B. I shewed you yesterday in discoursing of Rain, how by this compounded Motion of the Suns Body, the Air was every way at once thrust off West and East; so that where it was contiguous, the small parts of the water were forced to rise, for the avoiding of *Vacuum*. Think then that your hand were in the place of water so exposed to the Sun. Must not the Sun work upon it as it did upon the Water? Though it break not the skin, yet it will give to the inner Fluids and looser parts of your hand, an Endeavour to get forth, which will extend the skin, and in some climates fetch up the bloud, and in time make the skin black. The Fire also will do the same to them that often sit with their naked skins too neer it. Nay, one may sit so neer (without touching it) as it shall blister or break the skin, and fetch up both spirits and bloud mixt into a putrid oyly matter sooner, than in a Furnace Oyl can be extracted out of a Plant.

A. But if the Water be above the Fire in a Kettle, what then will it do? Shall the particles of water go toward the Fire, as it did toward the Sun?

B. No. For it cannot. But the Motion of the parts of the Kettle which are caused by the Fire, shall dissipate the Water into Vapour till it be all cast out.

A. What

A. What is that you call Fire? Is it a hard or Fluid Body?

B. It is not any other Body but that of the ſhining coal; which coal, though extinguiſhed with Water, is ſtill the ſame Body. So alſo in a very hot Furnace, the hollow ſpaces between the ſhining coals, though they burn that you put into them, are no other Body than Air moved.

A. Is it not Flame?

B. No. For flame is nothing but a multitude of Sparks, and Sparks are but the Atomes of the Fewel diſſipated by the incredible ſwift Motion of the Movent, which makes every Spark to ſeem a hundred times greater than it is, as appears by this; That when a man ſwings in the Air a ſmall ſtick fired at one end (though the Motion cannot be very ſwift) yet the Fire will appear to the eye to be a long, ſtreight, or crooked Line. Therefore a great many ſparks together flying upward, muſt needs appear unto the ſight as one continued Flame. Nor are the ſparks ſtriken out of a Flint any thing elſe but ſmall particles of the ſtone, which by their ſwift Motion are made to ſhine. But that Fire is not a ſubſtance of it ſelf, is evident enough by this, that the Sun-beams paſſing through a Globe of Water will burn as other fire does. Which beams, if they were indeed Fire, would be quenched in the paſſage.

A. This

A. This is ſo evident, that I wonder ſo wiſe men as *Ariſtotle* and his followers, for ſo long a time could hold it for an Element, and one of the primary parts of the Univerſe. But the Natural heat of a man or other living Creature, whence proceedeth it? Is there any thing within their Bodies that hath this *compounded Motion?*

B. At the breaking up of a Deer I have ſeen it plainly in his Bowels as long as they were warm. And it is called the *Periſtaltique* Motion, and in the Heart of a Beaſt newly taken out of his Body; and this Motion is called *Syſtole and Diaſtole.* But they are both of them this compounded Motion, whereof the former cauſeth the food to Winde up and down through the guts, and the later makes the Circulation of the Blood.

A. What kind of Motion is the Cauſe of Cold? Methinks it ſhould be contrary to that which cauſeth Heat.

B. So it is in ſome reſpect. For ſeeing the Motion that begets Heat, tendeth to the ſeparation of the parts of the Body whereon it acteth, it ſtands with reaſon, that the Motion which maketh Cold, ſhould be ſuch as ſets them cloſer together. But contrary Motions are (to ſpeak properly) when upon two ends of a Line two Bodies move towards each other, the Effect whereof is to make them meet. But each of them (as to this Queſtion) is the ſame.

A. Do

A. Do you think (as many Philoſophers have held and now hold) that Cold is nothing but a privation of Heat?

B. No. Have you never heard the Fable of the Satyre that dwelling with a Huſbandman, and ſeeing him blow his fingers to warm them, and his Pottage to cool it, was ſo ſcandalized, that he ran from him, ſaying he would no longer dwell with one that could blow both Hot and Cold with one breath? Yet the Cauſe is evident enough. For the Air which had gotten a Calefactive power from his vital parts, was from his mouth and throat gently diffuſed on his fingers, and retained ſtill that power. But to cool his Pottage he ſtreightened the paſſage at his lips, which extinguiſhed the Calefactive Motion.

A. Do you think Wind the general Cauſe of Cold? If that were true, in the greateſt Winds we ſhould have the greateſt Froſts.

B. I mean not any of thoſe uncertain Winds which, I ſaid, were made by the Clouds, but ſuch as a Body moved in the Air makes to and againſt it ſelf. For it is all one Motion of the Air, whether it be carried againſt the Body, or the Body againſt it. Such a Wind as is conſtant (if no other be ſtirring) from Eaſt to Weſt made by the Earth turning dayly upon its own Centre. Which is ſo ſwift, as (except it be kept off by ſome hill) to kill a man, as by Experience hath been found by thoſe

thoſe who have paſſed over great Mountains, and ſpecially over the *Andies* which are oppoſed to the Eaſt. And ſuch is the Wind which the Earth maketh in the Air by her Annual Motion, which is ſo ſwift, as that (by the Calculation of Aſtronomers) to go Sixty miles in a minute of an hour. And therefore this muſt be the Motion which makes it ſo cold about the Poles of the Ecliptique.

A. Does not the Earth make the Wind as great in one part of the Ecliptique as in another?

B. Yes. But when the Sun is in *Cancer*, it tempers the Cold, and ſtill leſs and leſs, but leaſt of all in the Winter-Solſtice, where his beams are moſt oblique to the Superficies of the Earth.

A. I thought the greateſt Cold had been about the Poles of the Æquator.

B. And ſo did I once. But the reaſon commonly given for it is ſo improbable, that I do not think ſo now. For the Cauſe they render of it, is onely, that the Motion of the Earth is ſwifteſt in the Æquinoctial, and ſloweſt about the Poles; and conſequently (ſince Motion is the Cauſe of Heat, and Cold is but (as 'twas thought) a want of the ſame) they inferr'd that the greateſt Cold muſt be about the Poles of the Æquinoctial. Wherein they miſcounted. For not every Motion cauſeth Heat, but this agitation onely, which we call com-

compounded Motion; though ſome have alſo leadged Experience for that opinion; as that a Bullet out of a Gun will with its own ſwiftneſs melt. Which I never ſhall believe.

A. 'Tis a common thing with many Philoſophers to maintain their Fancies with any raſh report, and ſometimes with a Lye. But how is it poſſible that ſo ſoft a Subſtance as water ſhould be turned into ſo hard a Subſtance as Ice?

B. When the Air ſhaves the Globe of the Earth with ſuch ſwiftneſs, as that of Sixty miles in a minute of an hour, it cannot (where it meets with ſtill water) but beat it up into ſmall and undiſtinguiſhable bubbles, and involve it ſelf in them as in ſo many bladders or ſkins of Water. And Ice is nothing elſe but the ſmalleſt imaginable parts of Air and Water mixt; which is made hard by this compounded Motion, that keeps the parts ſo cloſe together, as not to be ſeparated in one place without diſordering the Motion of them all. For when a Body will not eaſily yield to the impreſſion of an external Movent in one place without yielding in all, we call it Hard; And when it does, we ſay 'tis Soft.

A. Why is not Ice as well made in a moved as in a ſtill water? Are there not great Seas of Ice in the Northern parts of the Earth?

B. Yes, and perhaps alſo in the Southern parts. But I cannot imagine how Ice can be made

made in ſuch agitation as is always in the open Sea made by the Tides and by the Winds. But how it may be made at the Shoar, it is not hard to imagine. For in a River or Current, though ſwift, the water that adhereth to the banks is quiet, and eaſily by the Motion of the Air driven into ſmall inſenſible bubbles; and ſo may the water that adhereth to thoſe bubbles, and ſo forwards till it come into a ſtream that breaks it, and then it is no wonder though the fragments be driven into the open Sea, and freeze together into greater lumps. But when in the open Sea, or at the Shoar, the Tide or a great Wave ſhall ariſe, this young and tender Ice will preſently be waſht away. And therefore I think it evident, that as in the *Thames* the Ice is firſt made at the banks where the Tide is weak or none, and broken by the ſtream comes down to *London*, and part goes to the Sea floating till it diſſolve, and part (being too great to paſs the Bridge) ſtoppeth there and ſuſtains that which follows, till the River be quite frozen over: So alſo the Ice in the Northern Seas begins firſt at the banks of the Continent and Iſlands which are ſcituated in that Climate, and then broken off, are carried up and down, and one againſt another, till they become great Bodies.

A. But what if there be Iſlands, and narrow Inlets of the Sea, or Rivers alſo about the Pole of the Æquinoctial?

B. If there be, 'tis very likely the Sea may alſo there be covered all over with Ice. But for the truth of this, we muſt ſtay for ſome further diſcovery.

A. When the Ice is once made and hard, what diſſolves it?

B. The Principal Cauſe of it, is the weight of the water it ſelf; but not without ſome abatement in the Stream of the Air that hardned it; as when the Sun-beams are leſs oblique to the Earth, or ſome contrary Wind reſiſteth the ſtream of the Air. For when the impediment is removed, then the nature of the water only worketh, and (being a heavie Body) downward.

A. I forgot to aſk you, Why two pieces of Wood rub'd ſwiftly one againſt another, will at length ſet on fire.

B. Not onely at length, but quickly, if the Wood be dry. And the Cauſe is evident, *viz.* the compounded Motion which diſſipates the external ſmall parts of the Wood. And then the inner parts muſt of neceſſity (to preſerve the Plenitude of the Univerſe) come after; firſt the moſt Fluid, and then thoſe alſo of greater conſiſtence, which are firſt erected, and (the Motion continued) made to flie ſwiftly out; whereby the Air driven to the Eye of the beholder, maketh that fancie which is called *Light*.

A. Yes. I remember you told me before, that

that upon any ſtrong preſſure of the Eye, the reſiſtance from within would appear a *Light*. But to return to the enquiry of Heat and Cold, there be two things that beyond all other put me into admiration. One is the ſwiftneſs of kindling in Gunpowder. The other is the freezing of Water in a Veſſel (though not far from the fire) ſet about with other water with Ice and Snow in it. When Paper or Flax is flaming, the flame creeps gently on; and if a houſe full of Paper were to be burnt with putting a Candle to it, it will be long in burning; whereas a ſpark of fire would ſet on flame a mountain of Gunpowder in almoſt an inſtant.

B. Know you not Gunpowder is made of the powder of Charcole, Brimſtone, and Saltpeter? Whereof the firſt will kindle with a ſpark, the ſecond flame as ſoon as toucht with fire; and the third blows it, as being compoſed of many Orbs of Salt fill'd with Air, and as it diſſolveth in the flame, furiouſly blowing increaſeth it. And as for making Ice by the fire ſide. It is manifeſt that whilſt the Snow is diſſolving in the external veſſel, the Air muſt in the like manner break forth, and ſhave the Superficies of the inner veſſel, and work through the water till it be frozen.

A. I could eaſily aſſent to this, if I could conceive how the Air that ſhaves (as you ſay) the outſide of the Veſſel, could work through

it. I conceive well enough a pail of water with Ice or Snow diſſolving in it, and how it cauſeth Wind. But how that Wind ſhould communicate it ſelf through the veſſel of wood or metal, ſo as to make it ſhave the Superficies of the water which is within it, I do not ſo well underſtand.

B. I do not ſay the inner Superficies of the veſſel ſhaves the water within it. But 'tis manifeſt that the Wind made in the Pail of water by the melting Snow or Ice preſſeth the ſides of the Veſſel that ſtandeth in it; and that the preſſure worketh clean through, how hard ſoever the Veſſel be; and that again worketh on the water within, by reſtitution of its parts, and ſo hardeneth the water by degrees.

A. I underſtand you now. The Ice in the Pail by its diſſolution transfers its Hardneſs to the water within.

B. You are merry. But ſuppoſing, as I do, that the Ice in the Pail is more than the water in the Veſſel, you will finde no abſurdity in the Argument. Beſides, the Experiment, you know, is common.

A. I confeſs it is probable. The *Greeks* have the word Φείκη (whence the *Latins* have their word *Frigus*) to ſignifie the curling of water by the Wind; and uſe the ſame alſo for Horrour, which is the paſſion of one that cometh ſuddenly into a cold Air, or is put into

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a ſudden affright, whereby he ſhrinks, and his hair ſtands upright. Which manifeſtly ſhews that the Motion which cauſeth Cold, is that which preſſing the Superficies of a Body, ſets the parts of it cloſer together. But to proceed in my Quæries. Monſieur *Des Cartes*, who (you know) hath written ſomewhere, that the noiſe we hear in Thunder, proceeds from breaking of the Ice in the Clouds; What think you of it? Can a Cloud be turned into Ice?

B. Why not? A Cloud is but Water in the Air.

A. But how? For he has not told us that.

B. You know that 'tis onely in Summer, and in hot weather, that it Thunders; or if in Winter, it is taken for a Prodigie. You know alſo, that of Clouds, ſome are higher, ſome lower, and many in number, as you cannot but have oftentimes obſerved, with ſpaces between them. Therefore, as in all Currents of water, the Water is there ſwifteſt where it is ſtreightned with Iſlands, ſo muſt the Current of Air made by the Annual Motion be ſwifteſt there, where it is checkt with many Clouds through which it muſt (as it were) be ſtrained, and leave behinde it many ſmall particles of earth, always in it, and in hot weather more than ordinary.

A. This I underſtand, and that it may cauſe Ice. But when the Ice is made, how is it broken? And why falls it not down in ſhivers?

B. The particles are incloſed in ſmall Caverns of the Ice; and their Natural Motion being the ſame which we have aſcribed to the Globe of the Earth, requires a ſufficient ſpace to move in. But when it is impriſoned in a leſs room than that, then a great part of the Ice breaks: And this is the Thunder-clap. The Murmur following is from the ſettling of the Air. The Lightening is the fancie made by the recoiling of the Air againſt the Eye. The fall is in Rain, not in Shivers; becauſe the priſons which they break are extreme narrow, and the ſhivers being ſmall, are diſſolved by the Heat. But in leſs Heat they would fall in Drops of Hail, that is to ſay, half frozen by the ſhaving of the Air as they fall, and be in a very little time (much leſs than Snow or Ice) diſſolved.

A. Will not that Lightning burn?

B. No. But it hath often kill'd men with Cold. But this extraordinary ſwiftneſs of Lightning conſiſteth not in the Expanſion of the Air, but in a ſtraight and direct ſtream from where it breaks forth; which is in many places ſucceſſively, according to the Motion of the Cloud.

A. Experience tells us that. I have now done with my Problems concerning the great Bodies of the world, the Stars, and Element of Air in which they are moved, and am therein ſatisfied, and the rather, becauſe you have anſwered

ſwered me by the Suppoſition of one onely Motion, and commonly known, and the ſame with that of *Copernicus*, whoſe Opinion is received by all the Learned; and becauſe you have not uſed any of theſe empty terms, Sympathy, Antipathy, Antiperiſtaſis, *&c.* for a natural Cauſe, as the old Philoſophers have done to ſave their credit. For though they were many of them wiſe men, as *Plato*, *Ariſtotle*, *Seneca*, and others, and have written excellently of Morals and Politiques, yet there is very little Natural Philoſophy to be gathered out of their Writings.

B. Their Ethiques and Politiques are pleaſant reading, but I finde not any argument in their diſcourſes of Juſtice or Vertue drawn from the ſupreme Authority, on whoſe Laws all Juſtice, Vertue, and good Politiques depend.

A. Concerning this Cover, or (as ſome have called it) the Scurf or Scab of the Terreſtrial Star, I will begin with you to morrow. For it is a large Subject, containing Animals, Vegetables, Metals, Stones, and many other kinds of Bodies, the knowledge whereof is deſired by moſt men, and of the greateſt and moſt general profit.

B. And this is it, in which I ſhall give you the leaſt ſatisfaction; ſo great is the variety of Motion, and ſo concealed from humane ſenſes.

Cap. VII.

Of Hard and Soft, and of the Atomes that flie in the Air.

A. CConcerning this Cover of the Earth, made up of an infinite number of parts of different natures, I had much ado to finde any tolerable method of enquiry. But I resolved at last to begin with the Questions concerning *Hard* and *Soft*, and what kinde of Motion it is that makes them so. I know that in any pulsion of Air, the parts of it go innumerable and inexplicable ways; but I ask only if every point of it be moved.

B. No. If you mean a Mathematical point, you know it is impossible. For nothing is movable but Body. But I suppose it divisible (as all other Bodies) into parts divisible. For no Substance can be divided into Nothings.

A. Why may not that Substance within our Bodies, which are called Animal spirits, be another kind of Body, and more subtile than the common Air?

B. I know not why, no more than you or any man else knows why it is not very Air, though purer perhaps than the common Air, as being strained through the blood into the Brain and Nerves.

Nerves. But howſoever that be, there is no doubt, but the leaſt parts of the common Air, (reſpectively to the whole) will eaſilier pierce (with equal Motion) the Body that reſiſteth them, than the leaſt parts of water. For it is by Motion onely that any mutation is made in any thing; and all things ſtanding as they did, will appear as they did. And that which changeth *Soft* into *Hard*, muſt be ſuch as makes the parts not eaſily to be moved without being moved all together; which cannot be done but by ſome Motion compounded. And we call *Hard*, that whereof no part can be put out of order without diſordering all the reſt; which is not eaſily done.

A. How Water and Air beaten into extreme ſmall Bubbles is hardned into Ice, you have told me already, and I underſtand it. But how a ſoft Homogeneous Body, as Air, or Water, ſhould be ſo hardned, I cannot imagine.

B. There is no hard Body that hath not alſo ſome degree of Gravity; and conſequently, being looſe, there muſt be ſome Efficient Cauſe, that is, ſome Motion, when it is ſevered from the Earth, to bring the ſame to it again. And ſeeing this compounded Motion gives to the Air and Water an Endeavour from the Earth, the Motion which muſt hinder it, muſt be in a way contrary to the compounded Motion of the Earth. For whatſoever, having been

been aſunder, comes together again, muſt come contrary ways, as thoſe that follow one another go the ſame way, though both move upon the ſame Line.

A. What Experiment have you ſeen to this purpoſe?

B. I have ſeen a drop of glaſs like that of the ſecond Figure, newly taken out of the furnace, and hanging at the end of an Iron rod, and yet Fluid, and let fall into the water and hardned. The Club-end of it A A coming firſt to the water, the tail B C following it. 'Tis proved before, that the motion that makes it is a compounded Motion, and gives an Endeavour outward to every part of it; and that the Motion which maketh Cold, is ſuch as ſhaving the Body in every point of contact, and turning it, gives them all an Endeavour inward. Such is this Motion made by the ſinking of the hot and fluid glaſs into the water. 'Tis therefore manifeſt that the Motion which hardneth a *Soft* Body, muſt in every point of contact be in the contrary way to that which makes a hard body Soft. And further, that ſlender tail B C ſhall be made much more hard than common Glaſs. For towards the upper end, in C, you cannot eaſily break it, as ſmall as it is. And when you have broken it, the whole Body will fall into duſt, as it muſt do, ſeeing the bending is ſo difficult. For all the parts are bent with ſuch force, that upon

upon the breaking at D, by their ſudden reſtitution to their liberty, they will break together. And the cauſe why the tail B C, being ſo ſlender, becomes ſo hard, is, that all the Endeavour in the great part A B, is propagated to the ſmall part B C, in the ſame manner as the force of the Sun-beams is derived almoſt to a point by a Burning-glaſs. But the Cauſe why, when it is broken in D, it breaks alſo in ſo many other places, is, that the Endeavour in all the other parts (which is called the *Spring*) unbends it; from whence a Motion is cauſed the contrary way, and that Motion continued bends it more the other way and breaks it, as a Bow over-bent is broken into ſhivers by a ſudden breaking of the ſtring.

A. I conceive now how a Body which having been Hard and ſoftned again, may be rehardned; but how a Fluid and meer Homogeneous Body, as Air or Water, may be ſo, I ſee not yet. For the hardning of water is making a hard Body of two Fluids, whereof one (which is the water) hath ſome tenacity; and ſo a man may make a Bladder hard with blowing into it.

B. As for meer Air, which hath no Natural Motion of it ſelf, but is moved onely by other Bodies of a greater conſiſtence, I think it impoſſible to be hardned. For the parts of it ſo eaſily change places, that they can never be fixt by any Motion. No more I think can Water,

Water, which though ſomewhat leſs Fluid, is with an inſenſible force very eaſily broken.

A. It is the opinion of many learned men, that Ice (in long time) will be turned into Chriſtal; and they alleadge Experience for it. For they ſay that Chriſtal is found hanging on high Rocks in the *Alps* like Iſicles on the Eaves of a houſe, and why may not that have formerly been Ice, and in many years have loſt the power of being reduced?

B. If that were ſo, it would ſtill be Ice, though alſo Chriſtal: Which cannot be, becauſe Chriſtal is heavier than Water, and therefore much heavier than Ice.

A. Is there then no tranſubſtantiation of Bodies but by mixture?

B. Mixture is no tranſubſtantiation.

A. Have you never ſeen a Stone that ſeemed to have been formerly Wood, and ſome like Shells, and ſome like Serpents, and others like other things?

B. Yes. I have ſeen ſuch things, and particularly I ſaw at *Rome* in a Stone-cutters work-houſe a Billet of Wood, as I thought it, partly covered with bark, and partly with the grain bare, as long as a mans Arm, and as thick as the Calf of a mans Leg; which handling I found extreme heavie, and ſaw a ſmall part of it which was poliſhed, and had a very fine Gloſs, and thought it a ſubſtance between Stone and Metal, but neereſt to Stone. I have

have ſeen alſo a kind of Slate painted naturally with Foreſt-work. And I have ſeen in the hands of a Chymiſt of my acquaintance at *Paris*, a broken Glaſs, part of a Retort, in which had been the Rozin of Turpentine, wherein though there were left no Rozin, yet there appeared in the piece of Glaſs many Trees; and Plants in the ground about them, ſuch as grow in Woods; and better deſigned than they could be done by any Painter; and continued ſo for a long time. Theſe be great wonders of Nature, but I will not undertake to ſhew their cauſes. But yet this is moſt certain, that nothing can make a hard Body of a Soft, but by ſome Motion of its parts. For the parts of the Hardeſt Body in the world can be no cloſer together than to touch; and ſo cloſe are the parts of Air and Water, and conſequently they ſhould be equally Hard, if their ſmalleſt parts had not different Natural Motions. Therefore if you aſk me the Cauſes of theſe Effects, I anſwer, They are different Motions. But if you expect from me how and by what Motions, I ſhall fail you. For there is no kind of Subſtance in the World now, that was not at the firſt Creation, when the Creator gave to all things what Natural and ſpecial Motion he thought good. And as he made ſome Bodies wondrous great, ſo he made others wondrous little. For all his works are wondrous. Man can but gueſs, nor

gueſs

gueſs further, than he hath knowledge of the variety of Motion. I am therefore of opinion, that whatſoever perfectly Homogeneous is Hard, conſiſteth of the ſmalleſt parts (or, as ſome call them, Atomes) that were made Hard in the beginning, and conſequently by an Eternal Cauſe; and that the hardneſs of the whole Body is cauſed onely by the contact of the parts by preſſure.

A. What Motion is it that maketh a hard Body to melt?

B. The ſame compounded Motion that heats, namely, that of Fire, if it be ſtrong enough. For all Motion compounded is an Endeavour to diſſipate (as I have ſaid before) the parts of the Body to be moved by it. If therefore hardneſs conſiſt onely in the preſſing Contact of the leaſt parts, this Motion will make the ſame parts ſlide off from one another, and the whole to take ſuch a figure as the weight of the parts ſhall diſpoſe them to, as in Lead, Iron, Gold, and other things melted with Heat. But if the ſmall parts have ſuch figures as they cannot exactly touch, but muſt leave ſpaces between them filled with Air or other Fluids, then this Motion of the fire, will diſſipate thoſe parts ſome one way, ſome another, the Hard part ſtill hard; as in the burning of Wood or Stone into Aſhes or Lime. For this Motion is that which maketh Fermentation, ſcattering diſſimilar parts, and congregating ſimilar.

A. Why

A. Why do ſome hard Bodies reſiſt breaking more one way than another?

B. The Bodies that do ſo, are for the moſt part Wood, and receive that quality from their generation. For the heat of the Sun in the Spring-time draweth up the moiſture at the Root, and together with it the ſmall parts of the Earth, and twiſteth it into a ſmall twig by its Motion upwards to ſome length, but to very little other dimenſions, and ſo leaves it to dry till the Spring following; and then does the ſame to that, and to every ſmall part round about it; ſo that upward the ſtrength is doubled, and the next year trebled, *&c.* And theſe are called the grain of the Wood, and but touch one another, like ſticks with little or no binding, and therefore can hardly be broken acroſs the grain, but eaſily all-along it. Alſo ſome other hard Bodies have this quality of being more fragile one way than another, as we ſee in quarrels of a Glaſs-window, that are apteſt many times to break in ſome crooked Line. The cauſe of this may be, that when the glaſs, hot from the Furnace, is poured out upon a Plain, any ſmall ſtones in or under it will break the ſtream of it into divers lines, and not onely weaken it, but alſo cauſe it falſly to repreſent the Object you look on through it.

A. What is the Cauſe why a Bow of Wood or Steel, or other very hard Body, being bent, but

but not broken, will recover its former degree of ſtraightneſs?

B. I have told you already, how the ſmalleſt parts of a hard Body have every one (by the generation of hardneſs) a Circular, or other compounded Motion; ſuch Motion is that of the ſmalleſt parts of the Bow. Which Circles in the bending you preſs into narrower figures, as a Circle into an Ellipſis, and an Ellipſis into a narrower but longer Ellipſis with violence; which turns their Natural Motion againſt the outward parts of the Bow ſo bent, and is an Endeavour to ſtretch the Bow into its former poſture. Therefore if the impediment be removed, the Bow muſt needs recover its former Figure.

A. 'Tis manifeſt; and the cauſe can be no other but that, except the Bow have Senſe.

B. And though the Bow had Senſe, and Appetite to boot, the Cauſe will be ſtill the ſame.

A. Do you think Air and Water to be pure and Homogeneous Bodies?

B. Yes, and many Bodies both Hard and Heavie to be ſo too, and many liquors alſo beſides water.

A. Why then do men ſay they finde one Air healthy, another infectious?

B. Not becauſe the nature of the Air varies, but becauſe there are in the Air drawn, or rather, beaten up by the Sun, many little Bodies,

Bodies, whereof ſome have ſuch Motion as is healthful, others ſuch as is hurtful to the life of man. For the Sun (as you ſee in the generation of Plants) can fetch up Earth as well as Water; and from the drieſt ground any kind of Body that lieth looſe, ſo it be ſmall enough, rather than admit any Emptineſs. By ſome of theſe ſmall Bodies it is that we live; which being taken in with our breath, paſs into our blood, and cauſe it (by their compounded Motion) to circulate through the Veins and Arteries; which the blood of it ſelf (being a heavie Body) without it cannot do. What kind of ſubſtance theſe Atomes are, I cannot tell. Some ſuppoſe them to be Nitre. As for thoſe infectious creatures in the Air, whereof ſo many die of the Plague, I have heard that Monſieur *Des Cartes*, a very ingenious man, was of opinion, that they were little Flies. But what grounds he had for it, I know not, though there be many Experiments that invite me to believe it. For firſt, we know that the Air is never univerſally infected over a whole Country, but onely in or neer to ſome populous Town. And therefore the cauſe muſt alſo be partly aſcribed to the multitude thronged together, and conſtrained to carry their Excrements into the fields round about and neer to their habitation. Which in time fermenting breed Worms, which commonly in a month or little more, naturally become

come Flies; and though engendred at one Town, may flie to another. Secondly, in the beginning of a Plague, those that dwell in the Suburbs, that is to say, neereſt to this corruption, are the pooreſt of the people, that are nouriſhed for the moſt part with the Roots and Herbs which grow in that corrupted dirt; ſo that the ſame filth makes both the blood of poor people, and the ſubſtance of the Fly. And 'tis ſaid by *Ariſtotle*, that every thing is nouriſhed by the matter whereof it is generated. Thirdly, when a Town is infected, the Gentlemen, and thoſe that live on wholſomeſt food, ſcarce one of Five hundred die of the Plague. It ſeems therefore, whatſoever creatures they be that invade us from the Air, they can diſcern their proper nouriſhment, and do not enter into the mouth and noſtrils with the breath of every man alike, as they would do if they were inanimate. Fourthly, a man may carry the infection with him a great way into the Country in his Clothes, and infect a Village. Shall another man there draw the Infection from the Clothes onely by his breath? Or from the Hangings of a Chamber wherein a man hath died? It is impoſſible. Therefore whatſoever killing thing is in the Clothes or Hangings, it muſt riſe and go into his mouth or noſtrils before it can do him hurt. It muſt therefore be a Fly, whereof great numbers get into the blood, and there feeding and breeding

Worms,

Worms, obſtruct the Circulation of the blood, and kill the man.

A. I would we knew the palate of thoſe little Animals; we might perhaps finde ſome medicine to fright them from mingling with our breath. But what is that which kills men that lie aſleep too neer a Charcole-fire? Is it another kind of Fly? Or is Charcole venimous?

B. It is neither Fly nor venim, but the Effect of a flameleſs glowing fire, which diſſipates thoſe Atomes that maintain the circulation of the blood; ſo that for want of it, by degrees they faint, and being aſleep cannot remove, but in ſhort time, there ſleeping die, as is evident by this, that being brought into the open Air (without other help) they recover.

A. 'Tis very likely. The next thing I would be informed of, is the nature of Gravity. But for that, if you pleaſe, we will take another day.

Cap. VIII.

Of Gravity and Gravitation.

B. What Books are thoſe?

A. Two Books written by two learned men concerning *Gravity*. I brought them with me, becauſe they furniſh me with ſome material Queſtions about that Doctrine; though of the nature of Gravity, I finde no more in either of them than this, That Gravity is an Intrinſecal Quality by which a Body ſo qualified deſcendeth perpendicularly towards the Superficies of the Earth.

B. Did neither of them conſider that *deſcending* is *local Motion*, that they might have called it an intrinſecal *Motion* rather than an intrinſecal quality?

A. Yes. But not how Motion ſhould be intrinſecal to the ſpecial individual Body moved. For how ſhould they, when you are the firſt that ever ſought the differences of Qualities in local Motion, except your authority in Philoſophy were greater with them than it is? For 'tis hard for a man to conceive (except he ſee it) how there ſhould be Motion within a Body, otherwiſe than as it is in living creatures.

B. But

B. But it may be they never ſought, or deſpaired of finding what natural Motion could make any inanimate thing tend one way rather than another.

A. So it ſeems. But the firſt of them enquires no further than, Why ſo much water (being a heavie Body) as lies perpendicularly on a Fiſhes back in the bottom of the Sea, ſhould not kill it. The other (whereof the Author is Dr. *Wallis*) treateth univerſally of Gravity.

B. Well. But what are the Queſtions which from theſe Books you intend to aſk me?

A. The Author of the firſt Book tells me, that Water and other Fluids are Bodies continued, and act (as to Gravity) as a piece of Ice would do of the ſame Figure and quantity. Is that true?

B. That the Univerſe (ſuppoſing there is no place empty) is one entire Body, and alſo, as he ſaith it is, a continual Body, is very true. And yet the parts thereof may be contiguous, without any other coheſion but Touch. And it is alſo true, that a Veſſel of Water will deſcend in a *medium* leſs heavie (but Fluid) as Ice would do.

A. But he means that water in a Tub would have the ſame Effect upon a Fiſh in the bottom of the Tub, as ſo much Ice would have.

B. That alſo would be true, if the water were frozen to the ſides of it. Otherwiſe the

Ice (if there be enough) will cruſh the Fiſh to death. But how applies he this, to prove that the water cannot hurt a Fiſh in the Sea by its weight?

A. It plainly appears that Water does not Gravitate on any part of it ſelf beneath it.

B. It appears by Experience, but not by this Argument, though inſtead of Water the Tub were fill'd with Quickſilver.

A. I thought ſo. But how it comes to paſs that the Fiſh remains uncruſh'd, I cannot tell.

B. The Endeavour of the Quickſilver downward, is ſtopt by the reſiſtance of the hard bottom. But all Reſiſtance is a contrary Endeavour; that is, an Endeavour upwards, which gives the like Endeavour to the Quickſilver, which is alſo heavie, and thereby the Endeavour of the Quickſilver is diverted to the ſides round-about; where ſtopt again by the reſiſtance of the ſides, it receives an Endeavour upwards, which carries the Fiſh to the top, lying all the way upon a ſoft bed of Quickſilver. This is the true manner how the Fiſh is ſaved harmleſs. But your Author, I believe, either wanted age, or had too much buſineſs, to ſtudy the doctrine of Motion; and never conſidered that Reſiſtance is not an impediment onely, or privation, but a contrary Motion; and that when a man claps two pieces of Wax together, their contrary

Endea-

Endeavour will turn both the pieces into one Cake of Wax.

A. I know not the Author; but it ſeems he has deeplier conſidered this Queſtion than other men. For in the Introduction to his Book, he ſaith, *That men have pre-engaged themſelves to maintain certain Principles of their own invention, and are therefore unwilling to receive any thing that may render their labour fruitleſs:* and *That they have not ſtrictly enough conſidered the ſeveral interventions that abate, impede, advance, or direct the Gravitation of Bodies.*

B. This is true enough; and he himſelf is one of thoſe men, in that he conſidered not, that Reſiſtance is one of thoſe interventions, which abate, impede, and direct Gravitation. But what are his Suppoſitions for the Queſtion he handles?

A. His firſt is, That as in a Pyramide of Brick, wherein the Bricks are ſo joyned, that the uppermoſt lies every where over the joynt or Cement of the two next below it, you may break down a part, and leave a Cavity, and yet the Bricks above will ſtand firm and ſuſtain one another by their croſs poſture: So alſo it is in Wheat, Hail-ſhot, Sand, or Water; and ſo they arch themſelves, and thereby the Fiſh is every way ſecured by an arch of water over it.

B. That the cauſe why Fiſhes are not cruſht

nor hurt in the bottom of the Sea by the weight of the water, is the waters arching it ſelf, is very manifeſt. For if the uppermoſt Orb of the water ſhould deſcend by its Gravity, it would tend toward the Centre of the Earth, and place it ſelf all the way in a leſs and leſſer Orb; which is impoſſible. For the places of the ſame Body are always equal. But that Wheat, Sand, Hail-ſhot, or looſe Stones ſhould make a firm arch, is not credible.

A. The Author therefore (it ſeems) quits it: And taketh a ſecond Hypotheſis for the true Cauſe, though the former (he ſaith) be not uſeleſs, but contributes its part to it.

B. I ſee, though he depart from his Hypotheſis, he looks back upon it with ſome kindneſs. What is his ſecond Hypotheſis?

A. It is, That Air and Water have an Endeavour to Motion upward, downward, directly, obliquely, and every way. For Air (he ſaith) will come down his chimney, and in at his door, and up his ſtairs.

B. Yes, and mine too; and ſo would Water if I dwelt under water, rather than admit of *Vacuum*. But what of that?

A. Why then it would follow, that thoſe ſeveral tendencies or Endeavours would ſo abate, impede, and correct one another, as none of them ſhould Gravitate. Which being granted, the Fiſh can take no harm. Wherein I finde one difficulty. Which is this:

this: The Water having an Endeavour to Motion every way at once, methinks it ſhould go no way, but lie at reſt; which, he ſaith, was the opinion of *Stevinus*, and rejecteth it, ſaying, it would cruſh the Fiſh into pieces.

B. I think the Water in this caſe would neither reſt nor cruſh. For the Endeavour being (as he ſaith) intrinſecal, and every way, muſt needs drive the water perpetually outward, that is to ſay (as to this Queſtion) upwards; and ſeeing the ſame Endeavour in one individual Body cannot be more ways at once than one, it will carry it on perpetually without limit, beyond the fixed Stars; and ſo we ſhall never more have rain.

A. As ridiculous as it is, it neceſſarily follows.

B. What are Dr. *Wallis* his Suppoſitions?

A. He goes upon Experiments. And firſt he alleadgeth this, That Water left to it ſelf without diſturbance, does naturally ſettle it ſelf into a Horizontal Plain.

B. He does not then (as your Author and all other men) take Gravity for that Quality whereby a Body tendeth to the Centre of the Earth.

A. Yes, he defines Gravity to be a Natural propenſion towards the Centre of the Earth.

B. Then he contradicteth himſelf. For if all heavie Bodies tend naturally to one Centre, they ſhall never ſettle in a Plain, but in a Spherical

rical Superficies. But againſt this, That ſuch an Horizontal Plain is found in water by Experience, I ſay it is impoſſible. For the Experiment cannot be made in a Baſon, but in half a mile at Sea, Experience viſibly ſhews the contrary. According to this, he ſhould think alſo that a pair of Scales ſhould hang parallel.

A. He thinks that too.

B. Let us then leave this Experiment. What ſaies he further concerning Gravity?

A. He takes for granted (not as an Experiment, but an Axiome) that Nature worketh not by election, but *ad ultimum virium*, with all the power it can.

B. I think he means (for 'tis a very obſcure paſſage) that every inanimate Body by nature worketh all it can without election; which may be true. But 'tis certain that men (and beaſts) work often by election, and often without election; as when he goes by election, and falls without it. In this ſence I grant him, that Nature does all it can. But what infers he from it?

A. That naturally every Body has every way (if the ways oppoſe not one another) an Endeavour to Motion. And conſequently, that if a Veſſel have two holes, one at the ſide, another at the bottom, the water will run out at both.

B. Does he think the Body of water that runs

runs out at the ſide, and that which runs out at the bottom is but one and the ſame Body of water?

A. No ſure. He cannot think but that they are two ſeveral parts of the whole Water in the Veſſel.

B. What wonder is it then, if two parts of water run two ways at once, or a thouſand parts a thouſand ways? Does it follow thence that one Body can go more than one way at once? Why is he ſtill medling with things of ſuch difficulty? He will finde at laſt that he has not a Genius either for Natural Philoſophy or for Geometry. What other Suppoſitions has he?

A. My firſt Author had affirmed, that a lighter Body does not Gravitate on a heavier; againſt this Dr. *Wallis* thus argueth: Let there be a Siphon A B C D filled with Quickſilver to the level A D. If then you pour Oyl upon A as high as to E, he aſketh if the Oyl in A E (as being heavie) ſhall not preſs down the Quickſilver a little at A, and make it riſe a little at D, ſuppoſe to F. And anſwers himſelf, that certainly it will. So that it is neither an Experiment nor an Hypotheſis, but onely his opinion. Fig. 3.

B. Whatſoever it be, it is not true; though the Doctor may be pardoned, becauſe the contrary was never proved.

A. Can you prove the contrary?

B. Yes.

B. Yes. For the Endeavour of the Quick-ſilver both from A and D downward, is ſtronger than that of the Oyl downward. If therefore the Endeavour of the Quickſilver were not reſiſted by the bottom B C, it would fall ſo, by reaſon of the acceleration of heavie Bodies in their deſcending, as to leave the Oyl, ſo that it ſhould not onely not preſs, but alſo not touch the Quickſilver. It is true in a pair of Scales equally charged with Quickſilver, that the addition of a little Oyl to either Scale, will make it præponderate. And that was it deceiv'd him.

A. 'Tis evident. The laſt Experiment he cites is the weighing of Air in a pair of Scales, where 'tis found manifeſtly that it has ſome little weight. For if you weigh a Bladder, and put the weight into one Scale, and then blow the Bladder full of Air, and put it into the other Scale, the full Bladder will outweigh the empty. Muſt not then the Air Gravitate?

B. It does not follow. I have ſeen the Experiment juſt as you deſcribe it, but it can never be thence demonſtrated that Air has any weight. For as much Air as is preſt downward by the weight of the blown Bladder, ſo much will riſe from below, and lay it ſelf Spherically at the altitude of the Center of gravity of the Bladder ſo blown. So that all the Air within the Bladder above that Centre, is carried thither

thither impriſoned, and by violence: And the force that carries it up, is equal to that which preſſeth it down. There muſt therefore be allowed ſome little counterpoiſe in the other Scale to ballance it. Therefore the Experiment proves nothing to his purpoſe. And whereas they ſay there be ſmall heavie Bodies in the Air, which make it Gravitate, do they think the force which brought them thither cannot hold them there?

A. I leave this Queſtion of the Fiſh, as clearly reſolved, becauſe the water tending every way to one point (which is the Centre of the Earth) muſt of neceſſity arch it ſelf. And now tell me your own opinion concerning the Cauſe of Gravity, and why all Bodies deſcend or aſcend not all alike. For there can be no more Matter in one place than another if the places be equal.

B. I have already ſhewed you in general, that the difference of Motion in the parts of ſeveral Bodies makes the difference of their Natures. And all the difference of Motions conſiſteth either in ſwiftneſs, or in the way, or in the duration. But to tell you in Special, why Gold is heavieſt, and then Quickſilver, and then (perhaps) Lead, is more than I hope to know, or mean to enquire: for I doubt not but that the Species of heavie, hard, Opaque, and Diaphanous, were all made ſo at their creation, and at the ſame time ſepara-

ted

ted from different Species. So that I cannot gueſs at any particular Motions that ſhould conſtitute their natures, further than I am guided by the Experiments made by fire or mixture.

A. You hope not then to make Gold by Art?

B. No, unleſs I could make one and the ſame thing heavier than it was. God hath from the beginning made all the Kindes of Hard, and Heavie, and Diaphanous Bodies that are, and of ſuch Figure and magnitude as he thought fit; but how ſmall ſoever, they may by accretion become greater in the Mine, or perhaps by generation, though we know not how. But that Gold, by the art of man ſhould be made of not Gold, I cannot underſtand; nor can they that pretend to ſhew how. For the heavieſt of all Bodies, by what mixture ſoever of other Bodies, will be made lighter; and not to be received for Gold.

A. Why, when the Cauſe of Gravity conſiſteth in Motion, ſhould you deſpair of finding it?

B. It is certain, that when any two Bodies meet, as the Earth and any heavie Body will, the Motion that brings them to or towards one another, muſt be upon two contrary ways; and ſo alſo it is when two Bodies preſs each other in order to make them Hard. So that one contrariety of Motion might cauſe both

Hard

Hard and Heavie. But it doth not. For the hardeſt Bodies are not always the heavieſt. Therefore I finde no acceſs that way to compare the Cauſes of different Endeavours of heavie Bodies to deſcend.

A. But ſhew me at leaſt how any heavie Body that is once above in the Air, can deſcend to the Earth, when there is no viſible movent to thruſt or pull it down.

B. 'Tis already granted, that the Earth hath this compounded Motion ſuppoſed by *Copernicus*, and that thereby it caſteth the Contiguous Air from it ſelf every way round-about. Which Air ſo caſt off, muſt continually by its nature, range it ſelf in a Spherical Orb. Suppoſe a Stone (for inſtance) were taken up from the ground, and held up in the Air by a mans hand, what ſhall come into the place it fill'd when it lay upon the Earth?

A. So much Air as is equal to the Stone in magnitude, muſt deſcend and place it ſelf in an Orb upon the Earth. But then I ſee that to avoid *Vacuum*, another Orb of Air of the ſame magnitude muſt deſcend, and place it ſelf in that, and ſo perpetually to the mans hand; and then ſo much Air as would fill the place muſt deſcend in the ſame manner, and bring the Stone down with it. For the Stone having no Endeavour upward, the leaſt Motion of the Air (the hand being removed) will thruſt it downward.

B. 'Tis

B. 'Tis juſt ſo. And further, the Motion of the Stone downward ſhall continually be accelerated according to the odde numbers from Unity; as you know hath been demonſtrated by *Galileo*. But we are nothing the nearer by this, to the knowledge of why one Body ſhould have a greater Endeavour downward than another. You ſee the Cauſe of Gravity is this compounded Motion with excluſion of *Vacuum*.

A. It may be 'tis the Figure that makes the difference. For though Figure be not Motion, yet it may facilitate Motion, as you ſee commonly the breadth of a heavie Body retardeth the ſinking of it. And the cauſe of it is, That it makes the Air have further to go laterally, before it can riſe from under it. For ſuppoſe a Body of Quickſilver falling in the Air from a certain height, muſt it not (going as it does towards the Centre of the Earth) as it draws neerer and neerer to the Earth, become more and more ſlender, in the form of a Solid Sector? And if it have far to go, divide it ſelf into drops? This Figure of a Solid Sector is like a Needle with the point downward, and therefore I ſhould think that facilitating the Motion of it does the ſame that would be done by increaſing the Endeavour.

B. Do not you ſee that this way of facilitating is the ſame in Water, and in all other

Fluid

Fluid heavy Bodies. Beſides, your Argument ought to be applicable to the weighing of Bodies in a pair of Scales (which it is not, for there they have no ſuch Figure) it ſhould alſo hold in the compariſon of Gravity in Hard and Fluid Bodies.

A. I had not ſufficiently conſider'd it. But ſuppoſing now (as you do) that both heavy and hard Bodies, in their ſmalleſt parts, were made ſo in the Creation; yet, becauſe Quickſilver is harder than Water, a drop of Water ſhall in deſcending be preſt into a more ſlender Sector than a drop of Quickſilver, and conſequently the Earth ſhall more eaſily caſt off any quantity of Water than the ſame quantity of Quickſilver.

B. This one would think were true; as alſo that of ſimple Fluid Bodies, thoſe whoſe ſmalleſt parts, naturally, without the force of Fire do ſtrongleſt cohere, are generally the heavieſt. But why then ſhould Quickſilver be heavier than Stone or Steel? Fluidity and hardneſs are but degrees between greater Fluidity and greater hardneſs. Therefore to the knowledge of what it is that cauſeth the difference, in different Bodies, of their Endeavour downward, there are required (if it can be known at all) a great many more Experiments than have been yet made. It is not difficult to find why Water is heavier than Ice, or other Body mix'd of Air and Water. But

to believe that all Bodies are heavier or lighter according to the quantity of Air within them, is very hard.

A. I ſee by this, that the Creator of the World, as by his Power he ordered it, ſo by his Wiſdom he provided it ſhould be never diſordered. Therefore leaving this Queſtion, I deſire to know whether if a heavy Body were as high as a fixt Star, it would return to the Earth.

B. 'Tis hard to try. But if there be this compounded Motion in the great Bodies ſo high, ſuch as is in the Earth, it is very likely that ſome heavy Bodies will be carried to them. But we ſhall never know it till we be at the like height.

A. What think you is the reaſon why a drop of Water (though heavy) will ſtand upon a Horizontal Plain of dry or unctuous Wood, and not ſpread it ſelf upon it? For let A B (in the *6th* Figure) be the dry Plain, D the drop of Water, and D C perpendicular to A B. The drop D (though higher) will not deſcend and ſpread it ſelf upon it.

B. The reaſon I think is manifeſt. For thoſe Bodies which are made by beating of Water and Air together, ſhew plainly that the parts of Water have a great degree of Coheſion. For the ſkin of the Bubble is Water, and yet it can keep the Air (though moved) from getting out. Therefore the whole drop of

of Water at D, hath a good deal of Coheſion of parts. And ſeeing A B is an Horizontal Plain, the way from the contact in D either to A or B is upwards, and conſequently there is no endeavour in D either of thoſe ways, but what proceeds from ſo much weight of Water as is able to break that Coheſion, which ſo ſmall a drop is too weak to do. But the Coheſion being once broken, as with your Finger, the Water will follow.

A. Seeing the deſcent of a heavy Body increaſeth according to the odd numbers 1, 3, 5, 7, *&c.* and the aggregates of thoſe numbers, *viz.* of 1 and 3; and 1 and 3 and 5; and of 1 and 3 and 5 and 7, *&c.* are ſquare numbers, namely 4. 9. 16, the whole ſwiftneſs of the deſcent will be, I think, to the aggregate of ſo many ſwiftneſſes equal to the firſt Endeavour, as ſquare numbers are to their ſides, 1, 2, 3, 4. Is it ſo?

B. Yes, you know it hath been demonſtrated by *Galileo.*

A. Then if (for inſtance) you put into a pair of Scales equal quantities of Quickſilver and Water, ſeeing they are both accelerated in the ſame proportion, why ſhould not the weight of Quickſilver to the weight of Water be in duplicate proportions to their firſt Endeavours?

B. Becauſe they are in a pair Scales. For there the Motion of neither of them is accele-

rated. And therefore it will be, as the firſt Endeavour of the Quickſilver to the firſt endeavour of the Water, ſo the whole weight to the whole weight. By which you may ſee, that the Cauſe which takes away the Gravitation of Liquid Bodies from Fiſh or other lighter Bodies within them, can never be derived from the weight.

A. I have one Queſtion more to ask concerning Gravity. If Gravity be (as ſome define it) *an intrinſecal quality, whereby a Body deſcendeth towards the Center of the Earth,* how is it poſſible that a piece of Iron that hath this intrinſecal quality, ſhould riſe from the Earth, to go to a Loadſtone? Hath it alſo an intrinſecal quality to go from the Earth? It cannot be. The Cauſe therefore muſt be extrinſecal. And becauſe when they are come together in the Air, if you leave them to their own nature, they will fall down together, they muſt alſo have ſome like extrinſecal Cauſe. And ſo this magnetique vertue will be ſuch another vertue as makes all other heavy Bodies to deſcend (in this our World) to the Earth. If therefore you can from this your Hypotheſis of compounded Motion, by which you have ſo probably ſalved the Problem of Gravity, ſalve alſo this of the Loadſtone, I ſhall acknowledge both your Hypotheſis to be true, and your Concluſion to be well deduced.

B. I think it not impoſſible. But I will proceed no further in it now, than (for the facilitating of the demonſtrations) to tell you the ſeveral proprieties of the Magnet, whereof I am to ſhew the cauſes. As firſt, That Iron, and no other Body, at ſome little diſtance (though heavy) will riſe to it. Secondly, That if it be laid upon a ſtill Water in a floating Veſſel, and left to it ſelf, it will turn it ſelf till it lye in a Meridian, that is to ſay, with one and the ſame Line ſtill North and South. Thirdly, If you take a long ſlender piece of Iron, and apply the Loadſtone to it, and (according to the poſition of the Poles of the Loadſtone) draw it over to the end of the Iron, the Iron will have the ſame Poles with the Magnet, ſo it be drawn with ſome preſſure; but the Poles will lye in a contrary Poſition; and alſo this long Iron will draw other Iron to it as the Magnet doth. Fourthly, This long Iron, if it be ſo ſmall as that poiz'd upon a Pin, the weight of it have no viſible Effect, the Navigators uſe it for the Needle of their Compaſs, becauſe it points North and South; ſaving that in moſt places by particular accidents it is diverted; which diverſion is called the variation of the Horizontal Needle. Fifthly, The ſame Needle placed in a Plain perpendicular to the Horizon, hath another Motion called the Inclination. Which that you may the better conceive, draw a fourth Fig. 4.

Figure; wherein let there be a Circle to repreſent the *Terrella*, that is to ſay, a Spherical Magnet.

A. Let this be it, whoſe Center is A, the North Pole B, the South Pole C.

B. Join B C, and croſs it at right Angles with the Diameter D E.

A. 'Tis done.

B. Upon the point D ſet the Needle parallel to B C, with the croſs for the South Pole, and the Barb for the North; and deſcribe a Square about the Circle B D C E, and divide the arch D B into four equal parts in *a*, *b*, *c*.

A. 'Tis done.

B. Then place the middle of the Needle on the points *a*, *b*, *c*, ſo that they may freely turn; and ſet the Barb which is at D toward the North, and that which is at C towards the South. You ſee plainly by this, that the Angles of Inclination through the Arch D C taken all together, are double to a Right Angle. For when the South point of the Needle, looking North, as at D, comes to look South, as at C, it muſt make half a Circle.

A. That is true. And if you draw the Sine of the Arch D *a* (which is *d a*) and the Sine of the Arch B *a* (which is *a c*) and the Sine of the Arch D *b* (which is *b f*) and the Sine of the Arch B *c* (which is *c g*) the Needle will lye upon *b f* with the North-point downwards,

wards, ſo that the Needle will be parallel to A D. Then from *a* draw the line *a h*, making the Angle *e a h* equal to the Angle D A *a*. And then the Needle at *a* ſhall lye in the line *a h* with the South point toward *h*. Finally, draw the line *c h*, which (with *c g*) will alſo make a quarter of a right Angle; and therefore if the Needle be plac'd on the point *c* it will lye in *c h* with the South point toward *h*. And thus you ſee by what degrees the Needle inclines or dips under the Horizon more and more from D till it come to the North Pole at B; where it will lye parallel to the Needle in D; but with their Barbs looking contrary ways. And this is certain by experience, and by none contradicted.

B. You ſee then why the degrees of the Inclinatory Needle in coming from D to B are double to the degrees of a Quadrant. It is found alſo by experience, that Iron both of the Mine and of the Furnace put into a Veſſel ſo as to float, will lay it ſelf (if ſome accident in the Earth hinder it not) exactly North and South. And now I am, from this compounded Motion ſuppoſed by *Copernicus*, to derive the cauſes why a Loadſtone draws Iron; why it makes Iron to do the ſame; why naturally it placeth it ſelf in a parallel to the Axis of the Earth; why by paſſing it over the Needle it changes its Poles; and what is the cauſe that it inclines. But it is your part to remember

what I told you of Motion at our ſecond meeting; and what I told you of this compounded Motion ſuppoſed by *Copernicus*, at our fourth meeting.

CAP. IX.

Of the Loadſtone, and its Poles; and whether they ſhew the Longitude of places on the Earth.

A. I Come now to hear what Natural Cauſes you can aſſign of the vertues of the Magnet; and firſt, why it draws Iron to it, and only Iron.

B. You know I have no other cauſe to aſſign but ſome local Motion, and that I never approved of any argument drawn from Sympathy, Influence, Subſtantial Forms, or Incorporeal *Effluvia*. For I am not, nor am accounted by my Antagoniſts for a Witch. But to anſwer this Queſtion, I ſhould deſcribe the Globe of the Earth greater than it is at B in the firſt Figure, but that the *Terrella* in the fourth Figure will ſerve our turn. For 'tis but calling B and C the Poles of the Earth, and D E the Diameter of the Æquinoctial Circle, and making D the Eaſt, and E the Weſt. And then

then you muſt remember that the Annual Motion of the Earth is from Weſt to Eaſt, and compounded of a ſtraight and circular Motion, ſo as that every point of it ſhall deſcribe a ſmall Circle from Weſt to Eaſt, as is done by the whole Globe. And let the Circles about *a b c* be three of thoſe ſmall Circles.

A. Before you go any further, I pray you ſhew me how I muſt diſtinguiſh Eaſt and Weſt in every part of this Figure. For whereſoever I am on Earth (ſuppoſe at *London*) and ſee the Sun riſe (ſuppoſe in *Cancer*) is not a ſtraight line from my Eye to the Sun terminated in the Eaſt?

B. 'Tis not due Eaſt, but partly Eaſt, partly South. For the Earth (being but a point compared to the Sun) all the parallels to D E the Æquator, ſuch as are *e a*, *f b*, *c g*, if they be produced, will fall upon the Body of the Sun. And therefore A *b* is North-Eaſt; A *a* Eaſt North-Eaſt; And A *c* North North-Eaſt.

A. Proceed now to the Cauſe of Attraction.

B. Suppoſe now that the Internal parts of the Loadſtone had the ſame Motion with that of the Internal parts of the Sun which make the Annual Motion of the Earth from Weſt to Eaſt, but in a contrary way, for otherwiſe the Loadſtone and the Iron can never be made to meet. Then ſet the Loadſtone at a little diſtance from the Earth, marked with *z*; and

the

the Iron marked with *x* upon the ſuperficies of the Earth. Now that which makes *x* riſe to *z*, can be nothing elſe but Air; for nothing touches it but Air. And that which makes the Air to riſe, can be nothing but thoſe ſmall circles made by the parts of the Earth (ſuch as are at *a b c*,) for nothing elſe touches the Air. Seeing then the Motion of each point of the Loadſtone is from Eaſt to Weſt in Circles, and the motion of each point of the Iron from Weſt to Eaſt; it follows, that the Air between the Loadſtone and the Iron ſhall be caſt off both Eaſt and Weſt; and conſequently the place left empty, if the Iron did not riſe up and fill it. Thus you ſee the Cauſe that maketh the Loadſtone and the Iron to meet.

A. Hitherto I aſſent. But why they ſhould meet when ſome Heterogeneous Body lyes in the Air between them, I cannot imagine. And yet I have ſeen a Knife, though within the Sheath, attract one end of the Needle of a Mariners Compaſs; and have heard it will do the ſame though a Stone-wall were between.

B. Such Iron were indeed a very and vigorous Loadſtone. But the Cauſe of it is the ſame that cauſeth Fire or hot Water (which have the ſame compounded Motion) to work through a Veſſel of Braſs. For though the Motion be altered by reſtraint within the Hetero-

Heterogeneous Body, yet being continued quite through it reſtores it ſelf.

A. What is the Cauſe why the Iron rub'd over by a Loadſtone will receive the vertue which the Loadſtone hath of drawing Iron to it?

B. Since the Motion that brings two Bodies to meet muſt have contrary ways, and that the Motions of the Internal parts of the Magnet and of the Iron are contrary; the rubbing of them together does not give the Iron the firſt Edeavour to riſe, but multiplies it. For the Iron untouch'd will riſe to a Loadſtone; but if touch'd, it becomes a Loadſtone to other Iron. For when they touch a piece of Iron they paſs the Loadſtone over it only one way, *viz.* from Pole to Pole; not back again, for that would undo what before had been done; alſo they preſs it in paſſing, to the very end of the Iron, and ſomewhat hard. So that by this preſſing Motion all the ſmall Circles about the points *a b c*, are turned the contrary way. And the halves of thoſe ſmall Circles made on the Arch D B will be taken away, and the Poles changed, ſo as that the North-Poles ſhall point South, and the South Poles North, as in the Figure.

A. But how comes it to paſs, that when a Loadſtone hath drawn a piece of Iron, you may add to it another, as if they begat one another? Is there the like Motion in the generation of Animals?

B. I

B. I have told you that Iron of it ſelf will riſe to the Loadſtone. Much more then will it adhere to it when it is armed with Iron, and both it and the Iron have a plain Superficies. For then not only the points of Contact will be many (which make the coherence ſtronger) but alſo the Iron wherewith it is armed is now another Loadſtone, differing a little (which you perhaps think) as Male and Female. But whether this compounded Motion and confrication cauſeth the generation of Animals, how ſhould I know, that never had ſo much leaſure as to make any obſervation which might conduce to that?

A. My next Queſtion is, ſeeing you ſay the Loadſtone, or a Needle touch'd with it, naturally reſpecteth the Poles of the Earth, but that the variation of it proceedeth from ſome accidents in the Superficies of the Earth; what are thoſe accidents?

B. Suppoſe there be a Hill upon the Earth (for example) at *r*; then the ſtream of the Air which was between *z* and *x* Weſtward, coming to the Hill, ſhall go up the Hills ſide, and ſo down to the other ſide, according to the crooked Line which I have mark'd about the Hill by points; and this infallibly will turn the North-point of the Needle, being on the Eaſt ſide, more toward the Eaſt, and that on the other ſide more towards the Weſt, than if there had been no Hill. And where upon

upon the Earth are there not Eminencies and depreſſions, except in ſome wide Sea, and a great way from Land?

A. But if that be true, the Variation in the ſame place ſhould be always the ſame. For the Hills are not removed.

B. The Variation of the Needle at the ſame place is ſtill the ſame: but the Variation of the Variation is partly from the Motion of the Pole it ſelf, which by the Aſtronomers is called *Motus trepidationis*; and partly from that, that the Variation cannot be truly obſerv'd: for the Horizontal Needle and the Inclinatory Needle incline alike, but cannot incline in due quantity. For whether ſet upon a Pin or an Axis, their Inclination is hindred in the Horizontal Needle by the Pin it ſelf. If upon an Axis, if the Axis be juſt, it cannot move; if ſlack, the weight will hinder it. But chiefly becauſe the North Pole of the Earth draws away from it the North Pole of the Needle. For two like Poles cannot come together. And this is the cauſe why the Variation in one place is Eaſt, and another Weſt.

A. This is indeed the moſt probable reaſon why the Variation varies, that ever I heard given. And I ſhould preſently acknowledge that this parallel Motion of the Axis of the Earth in the Ecliptick, ſuppoſed by *Copernicus*, is the true Annual Motion of the Earth, but that there is lately come forth a Book called

called *Longitude found*, which makes the Magnetical Poles diſtant from the Poles of the Earth eight Degrees and a half.

B. I have the Book. 'Tis far from being demonſtrated, as you ſhall find if you have the patience to ſee it examined. For whereſoever his demonſtration is true, the concluſion (if rightly inferred) will be this, that the Poles of the Loadſtone and the Poles of the Earth are the ſame. And where on the contrary his demonſtrations are fallacies, it is becauſe ſometimes he fancieth the Lines he hath drawn, not where they are; ſometimes becauſe he miſtakes his ſtation; and ſometimes becauſe he goes on ſome falſe Principle of Natural Philoſophy; and ſometimes alſo becauſe he knoweth not ſufficiently the Doctrine of Spherical Triangles.

A. I think that's the Book there which lyes at your Elbow. Pray you read.

B. I find firſt (*Pag.* 4.) that the ground of his Argument are the two obſervations made by Mr. *Burroughs*; one at *Vaygates*, in 1676, where the Variation from the Pole of the Earth he found to be 11 deg. 15 min. Eaſt; the other at *Lime-houſe* near *London*, in 1580, where the Variation from the Pole of the Earth was 8 deg. 38 min. Weſt. By which he ſaith, he might *find out the Magnetical Pole.*

A. Where is *Vaygate?*

B. In

B. In 70 Degrees of North Latitude, the difference of Longitude between *London* and it being 58 Degrees.

A. The Longitude of places being yet to ſeek, how came he to know this difference of 58 Degrees, except the Poles of the Magnet and the Earth be the ſame?

B. I believe he truſted to the Globe for that. For the diſtance between the places is not above 2000 Miles the neareſt way. But we will paſs by that, and come to his Demonſtration, and to his Diagram, wherein L is *London*, P the North-Pole of the Earth, V *Vaygates*. So that L P is 38 deg. 28 min. P V 20 deg. the Angle L P V 58 deg. for the difference between the Longitudes of *Vaygates* and *London*. This is the Conſtruction. But before I come to the demonſtration, I have an Inference to draw from theſe obſervations, which is this. Becauſe in the ſame year the Variation at *London* was 11 deg. 15 min. Eaſt, and at *Vaygates* 8 deg. 38 min. Weſt; If you ſubſtract 11 deg. 15 min. from the Arc L P; and 8 deg. 38 min. from the Arc L V, the Variation on both ſides will be taken away; ſo that P V being the Meridian of *Vaygates*, and L P the Meridian of *London*, they ſhall both of them meet in P the Pole of the Earth. And if the Pole of the Magnet be nearer to the Zenith of *London* than is the Pole of the Earth, it ſhall be

be juſt as much nearer to the Zenith of *Vaygates* in the Meridian of *Vaygates* which is P V; as is manifeſt by the Diurnal Motion of the Earth.

A. All this I conceive without difficulty. Proceed to the Demonſtration.

B. Mark well now. His words are theſe, (*Pag.* 5.) *From P L V ſubſtract* 11 *deg.* 15 *min. and there remains the Angle V L M.* Conſider now which is the Angle P L V, and which is the remaining Angle V L M, and tell what you underſtand by it.

A. He has mark'd the Angle P L V with two numbers, 11 deg. 15 min. and 21 deg. 50 min. which together make 33 deg. 5 min. And the Angle 11 deg. 15 min. being ſubſtracted from P L V, there will remain 21 deg. 50 min. for the Angle V L M. I know not what to ſay to it. For I thought the Arc P V, which is 20 deg. had been the Arc of the Spherical Angle P L V; and that the Arc L V had been 58 deg. becauſe he ſays the Angle L P V is ſo; and that the Arc L M had been 46 deg. becauſe the Angle L P M is ſo; and laſtly, that the Angle P L M had been 8 deg. 30 min. becauſe the Arc P M is ſo.

B. And what you thought had been true, if a Spherical Angle were a very Angle. For all Men that have written of Spherical Triangles take for the ground of their calculation (as *Regiomontanus*, *Copernicus*, and *Clavius*,) that

that the Arch of a Spherical Angle is the ſide oppoſite to the Angle. You ſhould have conſidered alſo that he makes the Angle V P M 12 deg. but ſets down no Arc to anſwer it. But that you may find I am in the right, look into the Definitions which *Clavius* hath put down before his Treatiſe of *Spherical Triangles*, and amongſt them is this; *The Arc of a Spherical Triangle is a part of a great Circle intercepted between the two ſides drawn from the Pole of the ſaid great Circle.*

A. The Book is nothing worth; for it is impoſſible to ſubſtract an Arc of a Circle out of a Spherical Angle. And I ſee beſides that he takes the Superficies that lyeth between the ſides L P and L M for an Arch, which is the quantity of an Angle; and is a Line, and cannot be taken out of a Superficies. I wonder how any Man that pretends to Mathematicks could be ſo much miſtaken.

B. 'Tis no great wonder. For *Clavius* himſelf ſtriving to maintain that a right Angle is greater than the Angle made by the Diameter and the Circumference, fell into the ſame errour. A corner (in Vulgar Speech,) and an Angle (in the Language of Geometry) are not the ſame thing. But it is eaſie even for a learned Man ſometimes to take them for the ſame, as this Author now has done; and proceeding he ſaith, *Subſtract 8 deg. 38 min. from the Angle P V L, and there remains the Angle L V M.*

A. That

A. That again is false, because impossible. What was it that deceiv'd him now?

B. The same misunderstanding of the nature of a Spherical Angle. Which appears further in this, that when he knew the Arc V P was part of a great Circle, he thought V M (which he maketh 8 deg. 30 min.) were also parts of a great Circle; which is manifestly false. For two great Circles (because they pass through the Center) do cut each other into halves. But P V is not half a Circle. He sure thought himself at *Vaygates*, and that P M V was equal to P V, although in the same Hemisphere.

A. But how proves he that the Arc P M is 8 deg. 30 min?

B. Thus. *We have in two Triangles, P L M and P V M, two sides and one Angle included, to find P M the distance of the Magnetical Pole from the Pole of the Earth* 8 *deg.* 30 *min.*

A. Is that all? 'Tis very short for a Demonstration of two so difficult Problems, as the quantity of 8 deg. 30 min. and of the place of the Magnetical Pole. But he has proved nothing till he has shew'd how he found it. And though P M be 8 deg. 30 min. it follows not that M is the Magnetical Pole.

B. Nor is it true. For if P M be 8 deg. 30 min. and V M 8 deg. 38 min. the whole Arc P M V will be 17 deg. 8 min. which should be 20 deg. Besides, whereas the Variations

tions were East and West, the substracting of them should be also East and West, but they are North and South.

A. I am satisfied that the Magnetical Poles and the Poles of the Earth are the same. But thus much I confess, that if they were not the same, the Longitude were found. For the difference of the Latitudes of the Earths Æquator and of the Magnetical Æquator is the difference of the Longitude. But proceed.

B. The Earth being a solid Body, and the Magnetick Sphere that encompasseth the Earth being a substance that hath not solidity to keep pace with the Earth, looseth in its Motion. And that may be the Cause of the Motion of the Magnetick Poles from East to West.

A. This is very fine, and unexpected. The Magnetick Sphere (which I took for a Globe made of a Magnet) has not solidity to keep pace with the Earth, though it be one of the hardest Stones that are. *It encompasseth the Earth*; yet I thought nothing had encompassed the Earth but Air in which I breath and move. By this also the whole Earth must be a Loadstone. For two Bodies cannot be in one place. So that he is yet no further than Dr. *Gilbert* whom he sleights. And if the Sphere be a Magnet, then the Earth and Loadstone have the same Poles. See the force of Truth! which though it could not draw to it his reason, hath drawn his words to it.

B. But perhaps he meant that the Magnetick vertue encompaſſeth the Earth, and not the Magnetick Body.

A. But that helpeth him not. For if the Body of the Magnet be not there, the vertue then is the vertue of the Earth; and ſo again the Poles of the Earth are Magnetick Poles.

B. You ſee how unſafe it is to boaſt of Doctrines as of Gods gifts, till we are ſure that they are true. For God giveth and denieth as he pleaſeth, not as our ſelves wiſh; as now to him he hath given Confidence enough, but hath denied him (at leaſt hitherto) the finding of the Longitudes. In the next place (*Pag.* 8.) he ſeems much pleaſed that his Doctrine agrees with an opinion of *Keplerus*, That from the Creation to the year of our Lord it is to the year 1657 now 5650 years; and with that which he ſaith ſome Divines have held in times paſt, That as this World was created in ſix days, ſo it ſhould continue ſix thouſand years. By which account the World will be at an end 350 years hence; though the Scripture tell us it ſhall come as a Thief in the night. O what advantage 340 years hence will they have that know this, over them that know it not, by taking up Money at Intereſt, or ſelling Lands at 20 years purchaſe!

A. But he ſays he will not meddle with that.

B. Yes, when he had medled with it too much already.

A. But

A. But you have not told me wherein conſiſteth this Agreement between him and *Keplerus.*

B. I forgot it. 'Tis in the Motion of the Magnetick Poles. For precedently (*Pag.* 7.) he had ſaid *that their Period or Revolution was* 600 *years*; *their yearly Motion* 36 *min. and* (Pag. 8.) *that their Motion is by ſixes. Six tenths of a degree in one year*; *ſix degrees in ten year*; *ſixty degrees in a hundred year*; *and ſix times ſixty degrees in* 600 *year.*

A. But what Natural Cauſe doth he aſſign of this revolution of 600 years?

B. None at all. For the Magnet lying upon the Earth, can have no Motion at all but what the Earth and the Air give it. And becauſe it is always at 8 deg. 30 min. diſtance from the Pole of the Earth, the Earth can give it no other Motion than what it gives to its own Poles by the preceſſion of the Æquinoctial points. Nor can the Air give it any Motion but by its Stream; which muſt needs vary when the Stream varieth. But what a vaſt difference does he make between the period of the Motion of the Æquinoctial points, which are about or near 36000 years according to *Copernicus* (*Lib.* 3. *Cap.* 6.) which makes the Annual preceſſion to be 36 ſeconds, and the period of the Magnetical Poles Motion, which is but 600 years.

A. Go on.

B. He comes now (*Pag.* 15.) to the Inclinatory Needle upon a Spherical Loadſtone. Where he ſhews, by Diagram, that the Needle and the Inſtrument together moved toward the Magnetical Pole, make the ſum of the Inclinations equal to two Quadrants, ſetting the North-point of the Needle Southward. Which I confeſs is true. But (in the ſame Page) he aſcribeth the ſame Motion to the Earth in theſe words: *As the Horizontal Needle hath a double Motion about the Round Loadſtone or Terrulla, ſo alſo the Inclinatory Needle hath a double Motion about the Earth.* What is this, but a confeſſion that the Poles of the Magnet and of the Earth are the ſame?

A. 'Tis plain enough.

B. Beſides, ſeeing he placeth the Magnetical Pole at M in the Meridian of *Vaygates*, the Needle being touch'd ſhall Incline to the Pole of the Earth which is P, as well there as at *London*, and make the North-Pole of the Earth point South.

A. 'Tis certain, becauſe he puts both the Magnetical Pole and the Pole of the Earth in the ſame Meridian of the Earth. Nor ſee I any Cauſe why, the Needle being the ſame, it ſhould not be as ſubject to Variation, and to Variation of Variation, and to all Accidents of the Earth there, as in any other part.

B. He putteth (*Pag.* 16.) a Queſtion, *At what diſtance from the Earth are the Magnetick*

tick Poles? and anſwers to it, *They are very near the Earth, becauſe the nearer the Earth, the greater the ſtrength.* What think you of this?

A. I think they are in the Superficies of the Magnet, as the Pole of the Earth is in the Superficies of the Earth. And conſequently, that then the Earth muſt be a part of the Magnet, and their Poles the ſame. For the Body of the Magnet and the Body of the Earth, if they be two, cannot be in one place.

B. His next words are, *Some things are to be conſidered concerning thoſe Variations of the Horizontal Needle which are not according to the ſcituation of the place from the Magnetick Poles, but are contrary; as all the Weſt-Indies according to the Poles ſhould be Eaſterly, and they are Weſterly. Which is by ſome Accidental Cauſe in the Earth; and their Motion, as I formerly ſaid, is a forced Motion, and not Natural.*

A. He has clearly overthrown his main Doctrine. For to ſay the Motion of the Needle is forced and unnatural, is a moſt pityful ſhift, and manifeſtly falſe, no Motion being more conſtant or leſs accidental, notwithſtanding the Variation, to which the Inclinatory Needle is no leſs ſubject than the Horizontal Needle.

B. That which deceived him, was, that he thought them two ſorts of Needles, forgetting

what he had ſaid of *Norman's* Invention of the Inclinatory Needle by the inclining of the Horizontal Needle, *Pag.* 11. For I will ſhew you that what he ſays is Eaſterly and ſhould be Weſterly, ſhould be Eaſterly as it is. Conſider the fourth Figure, in which B is the North-Pole, and B *c* 11 deg. 15 min. Eaſterly, which was the Variation at *London* in 1576 Eaſterly. Suppoſe A *c* to be the Needle, ſhall it not incline, as well here as at D *a*, and the Variation B *c* be Eaſterly? Again, D *a* is 11 deg. 15 min. and the Needle in D parallel to A B, and at *a* inclining alſo 11 deg. 15 min. Weſterly. And is not the Variation there D *a* Weſterly, with the North-point of the Needle in the Line *a h*?

A. But the Weſt-Indies are not in this Hemiſphere B C D E. The Variation therefore will proceed in an Arc of the oppoſite Hemiſphere, which is Weſterly.

B. I believe he might think ſo, forgetting that he and his Compaſs were on the Superficies of the Earth, and fancying them in the Center at A.

A. 'Tis like enough. If we had a ſtraight Line exactly equal to the Arc of a Quadrant, I think it would very much facilitate the Doctrine of Spherical Triangles.

B. When you have done with your Queſtions of Natural Philoſophy, I will give you a clear Demonſtration of the equality of a ſtraight

ſtraight Line to the Arc of a Quadrant, which, if it ſatisfie you, you may carry with you, and try thereby if you can find the Angle of a Spherical Triangle given.

A. It is time now to give over. And at our next meeting I deſire your opinion concerning the Cauſes of Diaphaniety, and Refraction. This *Copernicus* has done much more than he thought of. For he has not only reſtored to us Aſtronomy, but alſo made the way open to Phyſiology.

Cap. X.

Of Tranſparence, Refraction; and of the Power of the Earth to produce living Creatures.

A. THinking upon what you ſaid yeſterday, it lookt like a generation of living Creatures. I ſaw the love between the Loadſtone and the Iron in their mutual attraction, their engendring in their cloſe and contrary Motion; and their iſſue in the Iron, which being touch'd hath the ſame attractive vertue. Now ſeeing they have the ſame internal motion of parts with that of the Earth, why ſhould not their ſubſtance be the ſame, or very near a kin? *B.* The

B. The moſt of them (if not all) that have written of this Subject, when they call the Loadſtone a *Terrella*, ſeem to think as you do. But I, except I could find proof for it, will not affirm it. For the Earth attracteth all kind of Bodies but Air, and the Loadſtone none but Iron. The Earth is a Star, and it were too bold to pronounce any ſentence of its ſubſtance, eſpecially of the Planets, that are ſo lapt up in their ſeveral Coats, as that they cannot work on our Eyes, or any Organ of our other Senſes.

A. I come therefore now to the buſineſs of the day. Seeing all Generation, Augmentation, and Alteration is local Motion, how can a Body not Tranſparent be made Tranſparent?

B. I think it can never be done by the Art of Man. For as I ſaid of Hard and Heavy Bodies in the Creation, ſo I think of Diaphanous, that the very ſame Individual Body which was not Tranſparent then, ſhall never be made Tranſparent by Humane Art.

A. Do not you ſee that every day Men make Glaſs, and other Diaphanous Bodies not much inferior in beauty to the faireſt Gems?

B. It is one thing to make one Tranſparent of many by mixture, and another to make Tranſparent of not Tranſparent. Any very hard Stone, if it be beaten into ſmall Sands, ſuch

ſuch as is uſed for Hour-Glaſſes, every one of thoſe Sands, if you look upon it with a Microſcope, you will find to be Tranſparent; and the harder and whiter the Sone is, ſo much the more Tranſparent, as I have ſeen in the Stone of which are made Milſtones, which Stone is here called Greet. And I doubt not but the Sands of white Marble muſt be more Tranſparent. But there are no Sands ſo Tranſparent that they have not a ſcurf upon them as hard, perhaps, as the Stone it ſelf; which they whoſe profeſſion it is to make Glaſs, have the Art to ſcour and waſh away. And therefore I think it no great wonder to bring thoſe Sands into one Lump, though I know not how they do it.

A. I know they do it with Lie made with a Salt extracted from the Aſhes of an Herb, of which Salt they make a ſtrong Lie, and mingle it with the Sand, and then bake it.

B. Like enough. But ſtill it is a Compound of two Tranſparent Bodies, whereof one is the Natural Stone, the other is the Morter. This therefore doth not prove, that one and the ſame Body, of not Tranſparent can be made Tranſparent.

A. Since they can make one Tranſparent Body of many, why do they not of a great many ſmall ſparks of natural Diamant compound one great one? It would bear the charges of all the Materials, and beſide, enrich them.

B. 'Tis

B. 'Tis probable it would. But it may be they know no Salt that howſoever prepared, which (with how great a Fire ſoever) can make them melt. And, it may be the true Chryſtal of the Mountain, which is found in great pieces in the *Alps*, is but a compound of many ſmall ones, and made by the Earths Annual Motion. For it is a very ſwift Motion. Suppoſe now that within a very ſmall Cavern of thoſe Rocks whoſe ſmalleſt Atomes are Chryſtal, and the Cavity fill'd with Air; and conſider what a tumult would be made by the ſwift reciprocation of that Air; whether it would not in time ſeparate thoſe Atomes from the Rock, and jumbling them together make them rub off their ſcruf from one another, and by little and little to touch one another in poliſh'd plains, and conſequently ſtick together, till in length of time they become one lump of clean Chryſtal.

A. I believe that the leaſt parts of created ſubſtances lay mingled together at firſt, till it pleaſed God to ſeparate all diſſimilar natures, and congregate the ſimilar, to which this *Annual Motion* is proper. But they ſay that Chryſtal is found in the open Air hanging like Icicles upon the Rocks. Which (if true) defeats this ſuppoſition of a narrow Cavern. And therefore I muſt have ſome further experience of it before I make it my opinion. But howſoever, it ſtill holds true that Diaphanous

phanous Bodies of all ſorts, in their leaſt parts, were made by God in the beginning of the World. But it may be true, notwithſtanding thoſe Icicles. For the force of the Air that could break off thoſe Diaphanous Atomes in a Cavern, can do the ſame in the open Air. And I know that a leſs force of Air can break ſome Bodies into ſmall pieces, not much leſs hard than Chyſtal, by corrupting them.

B. That which you now have ſaid is ſomewhat. But I deny not the poſſibility, but only doubt of the Operation. You may therefore paſs to ſome other Queſtion.

A. Well, I will ask you then a Queſtion about Refraction. I know already that for the Cauſe of Refraction (when the Light falleth through a thinner Medium upon a thicker) you aſſign the reſiſtance of the thicker Body; but you do not mean there by *Rarum* and *Denſum*, two Bodies whereof in equal ſpaces one has more ſubſtance in it than the other.

B. No. For equal ſpaces contain equal Bodies. But I mean by *Denſum* any Body which more reſiſteth the Motion of the Air, and by *Rarum* that which reſiſteth leſs.

A. But you have not declared in what that reſiſtance conſiſteth.

B. I ſuppoſe it proceedeth from the Hardneſs.

A. But from thence it will follow, that all Tranſparent Bodies that equally refract are equally

equally Hard. Which I think is not true, because the Refraction of Glaſs is not greater (at leaſt in compariſon of their Hardneſſes) than that of Water.

B. I confeſs it. Therefore I think we muſt take in Gravity to a Share in the production of this Refraction. For I never conſidered Refraction but in Glaſs; becauſe my buſineſs then was only to find the Cauſes of the *Phænomena* of Teleſcopes and Microſcopes. Let therefore A B (in *Fig.* 7.) be a hard, and conſequently, a heavy Body. And from above (as from the Sun) let C A be the line of Incidence, and produced to D. And draw A E perpendicular to A B. It is manifeſt that the Hardneſs in A B ſhall turn the ſtream of the Light inwards toward A E, ſuppoſe in the line A *e*. It is alſo evident that the Endeavour in B, which is (being heavy) downward, ſhall turn the ſtream again inward, towards A E as in A *b*. Thus it is in Refraction from the Sun downwards. In like manner, if the light come from below, as from a Candle in the point D, the line of Incidence will be D A, and produced will paſs to C. And the reſiſtance of the Hardneſs in A will turn the ſtream A C inward, ſuppoſe into B *l*, and make C *l* equal to D *e*. For paſſing into a thinner Medium, it will depart from the perpendicular in an Angle equal to the Angle D A *e*, by which it came nearer to it in A *e*.

So

So also the resistance of the Gravity in the point A shall turn the stream of the Light into the line A *i*, and make the Angle *l* A *i* equal to the Angle *e* A *b*. And thus you see in what manner, though not in what proportion Hardness and Gravity conjoyn their resistance in the Causing of Refraction.

A. But you proved yesterday, that a heavy Body does not Gravitate upon a Body equally heavy. Now this A B has upper parts, and lower parts; and if the upper parts do not Gravitate upon the lower parts, how can there be any Endeavour at all downward to contribute to the Refraction?

B. I told you yesterday, that when a heavy Body was set upon another Body heavier or harder than it self, the Endeavour of it downward was diverted another way, but not that it was extinguished. But in this case, where it lyeth upon Air, the first endeavour of the lowest part worketh downward. For neither Motion nor Body can be utterly extinguished by a less than an Omnipotent power. All Bodies as long as they are Bodies, are in Motion one way or other, though the farther it be communicated, so much the less.

A. But since you hold that Motion is propagated through all Bodies, how hard or heavy soever they be, I see no Cause but that all Bodies should be Transparent.

B. There are divers Causes that take away Tran-

Tranſparency. Firſt, if the Body be not perfectly Homogeneous, that is to ſay, if the ſmalleſt parts of it be not all preciſely of the ſame nature, or do not ſo touch one another as to leave no *Vacuum* within it; or though they touch, if they be not as hard in the contact as in any other line. For then the Refractions will be ſo changed both in their direction, and in their ſtrength, as that no Light ſhall come through it to the Eye; as in Wood and ordinary Stone and Metal. Secondly, The Gravity and hardneſs may be ſo great, as to make the Angle refracted ſo great, as the ſecond Refraction ſhall not direct the beam of light to the Eye; as if the Angle of Refraction were D A E, the Refracted line would be perpendicular to A B, and never come to the line A D, in which is the Eye.

A. To know how much of the Refraction is due to the Hardneſs, and how much to the Gravity, I believe it is impoſſible, though the Quantity of the whole be eaſily meaſured in a Diaphanous Body given. And both you and Mr. *Warner* have demonſtrated, that as the Sine of the Angle Refracted in one Inclination is to the Sine of the Angle Refracted in another Inclination, ſo is the Sine of one Inclination to the Sine of the Angle of the other Inclination. Which Demonſtrations are both publiſhed by *Merſennus* in the end of the firſt Volume of his *Cogitata Phyſico-Mathematica.*

But

But ſince there be many Bodies, through which though there paſs Light enough, yet no Object appears through them to the Eye, what is the reaſon of that?

B. You mean Paper. For Paper-Windows will enlighten a Room, and yet not ſhow the Image of an Object without the Room. But 'tis becauſe there are in Paper abundance of pores, through which the Air paſſing moveth the Air within; by the Reflections whereof any thing within may be ſeen. And in the ſame Paper there are again as many parts not Tranſparent, through which the Air cannot paſs, but muſt be reflected firſt to all parts of the Object, and from them again to the Paper; and at the Paper either reflected again or tranſmitted, according as it falls upon Pores or not Pores; ſo that the Light from the Object can never come together at the Eye.

A. There belongs yet to this Subject the Cauſes of the diverſity of Colours. But I am ſo well ſatisfied with that which you have written of it in the 24*th* Chapter of your Book *de Corpore*, that I need not trouble you further in it. And now I have but one Queſtion more to aſk you, which I thought upon laſt night. I have read in an antient Hiſtorian that Living Creatures after a great deluge were produced by the Earth, which being then very ſoft, there were bred in it (it may be by the rapid Motion of the Sun) many Bliſters,

which in time breaking, brought forth (like ſo many Eggs) all manner of living Creatures great and ſmall, which ſince it is grown hard it cannot do. What think you of it?

B. It is true that the Earth produced the firſt living Creatures of all ſorts but Man. For God ſaid, (*Gen.* 1. *verſ.* 24.) *Let the Earth produce every living Creature, Cattle, and creeping thing*, &c. But then again (*ver.* 25.) it is ſaid that *God made the Beaſt of the Earth*, &c. So that it is evident that God gave unto the Earth that vertue. Which vertue muſt needs conſiſt in Motion, becauſe all Generation is Motion. But Man, though the ſame day, was made afterward.

A. Why hath not the Earth the ſame vertue now? Is not the Sun the ſame it was? Or is there no Earth now ſoft enough?

B. Yes. And it may be the Earth may yet produce ſome very ſmall Living Creatures: And perhaps Male and Female. For the ſmalleſt Creatures which we take notice of, do engender, though they do not all by conjunction; therefore if the Earth produce living Creatures at this day, God did not abſolutely reſt from all his Works on the ſeventh day, but (as it is *Cap.* 2. *ver.* 2.) *he reſted from all the work he had made.* And therefore it is no harm to think that God worketh ſtill, and when and where and what he pleaſeth. Beſide, 'tis very hard to believe, that to produce

Male

Male and Female, and all that belongs thereto, as alſo the ſeveral and curious Organs of Senſe and Memory, could be the work of any thing that had not underſtanding. From whence, I think we may conclude, that whatſoever was made after the Creation, was a new Creature made by God no therwiſe than the firſt Creatures were, excepting only Man.

A. They are then in an Errour that think there are no more different kinds of Animals in the World now, than there were in the Ark of *Noah.*

B. Yes doubtleſs. For they have no Text of Scripture from which it can be proved.

A. The Queſtions of Nature which I could yet propound are innumerable. And ſince I cannot go through them, I muſt give over ſomewhere, and why not here? For I have troubled you enough, though I hope you will forgive me.

B. So God forgive us both as we do one another. But forget not to take with you the Demonſtration of a ſtraight Line equal to an Arc of a Circle.

FINIS.